Curbing Illicit Financial Flows from Resource-rich Developing Countries: Improving Natural Resource Governance to Finance the SDGs

Working Paper No. R4D-IFF-WP02-2020

Exporting Peruvian Copper Concentrate

An analysis of the price mechanisms and market practices in the export of Peruvian copper

May, 2020

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This project is funded through the Swiss Programme for Research on Global Issues for Development (www.r4d.ch) by the Swiss Agency for Development and Cooperation (SDC) and the Swiss National Science Foundation (SNSF).

Abstract

This study aims to assess the existence of trade mispricing in the export of Peruvian copper concentrate for the years 2003 to 2017. Using the price-filter methodology, the study conducts a quantitative analysis of abnormal pricing using the LME daily price series as free market price filter and customs records as trade statistics. The analysis is further supported by qualitative data collected from interviews with key stakeholders of the Peruvian mining sector, which helped determine the price filters used to establish the acceptable range for price deviations. Asymmetries were found between transaction prices and expected export prices across the data, which variate depending on the price filter used. However, an in-depth assessment of the results shows that the estimates of trade mispricing are not to be taken as straightforward indications of illicit financial flows. Instead, the sensitivity analysis and further data disaggregation highlight the need for further research and country-level approaches.

Table of Contents

1. Introduction

According to a 2014 estimate by UNCTAD, US$ 2.5 trillion per year is required for developing countries to achieve the United Nations Sustainable Development Goals (SDGs) by 2030 (UNCTAD, 2014). This projection far outstrips the available level of Official Development Assistance (ODA) currently estimated at US$ 152.8 billion (OECD, 2019).

In response to the above, the United Nations 2030 Agenda for Sustainable Development identified domestic resource mobilization (DRM) – a process focused in bolstering a country's fiscal capacity by e.g. broadening the tax base and strengthening tax administration institutions and revenue collection policies – as a more sustainable approach to development financing, especially since average tax-to-GDP ratios in the Global South are significantly lower than its Global North counterparts. Consequently, in its drive towards achieving the Sustainable Development Goals (SDGs), the 2030 Agenda adopted two targets related to taxation and illicit financial flows (Targets 16.4 and 17.1 respectively[1]) supported by the Addis Ababa Action Agenda of 2015[2].

Illicit financial flows, widely defined as cross-border movements of money that have been illegally earned, transferred, or utilized (Global Financial Integrity, 2008), erode a countries' domestic tax base and therefore pose a major challenge to those seeking to develop a more robust fiscal system. The problem is even more pertinent for resource-rich developing countries where the commodity trading sector constitutes a key source of public revenues and fiscal income, and where the sector's inherent complexity renders it particularly vulnerable to illicit financial flows (IFF) through trade mispricing[3]

Starting with the publication of Raymond Baker's Capitalism's Achilles Heel in 2005, often regarded as the starting point for discussions surrounding IFFs (Reuter, 2012), several studies have aimed to estimate the scale and magnitude of abnormal pricing and illicit financial flows, although results remain contested. Additionally, while the still nascent literature has sought to define the parameters and related concepts of IFFs, much ambiguity remains (Cobham and Janský, 2017; Erikkson, 2017; Forstater, 2018, Mehrotra, 2018, Musselli and Bürgi, 2018)[4]. Although this ambiguity can help build political momentum and bring flexibility into the debate, inconsistencies can be an impediment to academic research and further policy development (Forstater, 2018).

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1 Target 16.4 of the SDGs calls for "reducing illicit financial and arms flows", which is measured by an indicator on the "total value of inward and outward illicit financial flows". Additionally, target 17.1 highlights the need to strengthen domestic resource mobilization and improve the domestic capacity for tax and other revenue collection, measured by total government revenue and domestic taxes as a proportion of GDP and domestic budget. See https://sustainabledevelopment.un.org/

2 The Addis Ababa Action Agenda recognized the need to increase domestic public financing in order to achieve the SDGs and calls on countries to improve their efforts to mobilize domestic resources

3 **Trade mispricing** is an umbrella definition referring to incorrectly priced transactions by legally established business entities. Trade misinvoicing and transfer mispricing are two concepts under trade mispricing. A) **Trade misinvoicing** refers to the false report of the value, quantity, or nature of the exported or imported goods and services in a commercial transaction. This practice is a form of customs and/or tax fraud that is used to evade tariffs, custom duties, or trade restrictions on particular commodities or countries taxes. **Transfer mispricing** relates to the broad phenomenon of tax avoidance and is related to the sense of "illicitness". Transfer pricing regulations require related parties to handle under the arm's length principle. Abusive transfer pricing or transfer price manipulation refers to a manipulation of prices between affiliated companies or subsidiaries, such as under-invoicing to an affiliated firm in a low-tax jurisdiction or over-valuation of costs to decrease the tax base. This is highly beneficial for the company as a whole, but it ultimately undermines the first local tax jurisdiction.

4 In particular regarding: (i) the type of flows (do IFFs include only financial transfers or all assets of financial capital?); (ii) the degree of illegality (where to draw the line between legality, illicitness and illegality, and how can this be reflected in data?); and (iii) the appropriate legal standards (should IFFs fall under local or international jurisdiction?)

This paper aims to contribute to the existing literature in illicit financial flows, specifically commodity trade-related IFFs, by adopting a country-based approach and micro-type methodology to assess whether the Peruvian copper sector has been subject to trade mispricing. Peru is a fitting case for the study of illicit financial flows as it is a long-standing player in the mining industry, with rising production levels and expected investments, and has a strong presence of international mining firms and an existing regulatory framework. The country also provides access to trade statistics that are crucial for the study of IFFs.

Accordingly, the following questions are examined: do copper export statistics from Peruvian customs authorities show indications of abnormal pricing, which can hint at trade mispricing and further to the recognition of commodity trade-related illicit financial flows? If so, can the above be measured in an accurate manner?

The analysis uses the price-filter methodology to compare transaction-level export prices against the London Metal Exchange (LME) free-market daily price series, the latter which is selected as a benchmark price. In contrast to more aggregated studies, this paper uses disaggregated exports data on copper concentrate exports from the Peruvian Customs Authority, focusing on the period from 2003 to 2017. Qualitative data on local market practices and recording procedures is also used to inform the statistical analysis and help adopt assumptions that define the arm's price length of acceptable deviations, ultimately providing a more precise and accurate analysis.

Additionally, the analysis is done at two levels. First, I present the results for the entire period of study together with a sensitivity analysis for the selected price filters. These initial estimates are further analyzed for the year 2017 to include key information on the price composition of copper concentrate exports, which heavily influences the results. The assumptions taken in both cases are discussed in detail. Finally, I discuss different hypotheses to explain the observed asymmetries.

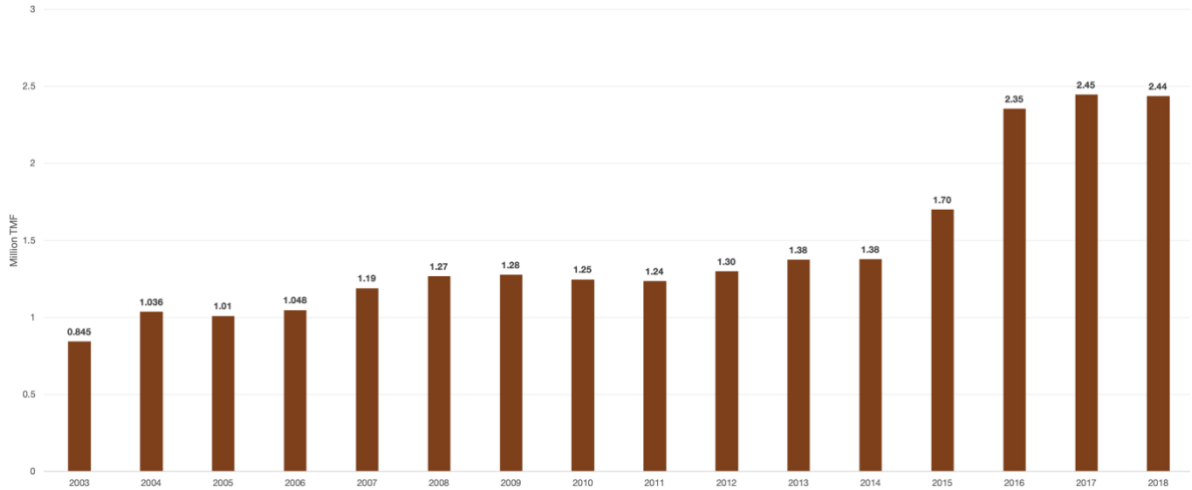
It is important to note that this research refrains from treating all trade gaps as illicit financial flows. Instead, the results serve as first indications of abnormal pricing which need to be further investigated. Further research is needed to combine the economic estimates with political economy analyses – specifically to identify critical regulatory loopholes. Findings from this study also provide recommendations that align to the Peruvian economic, political, and institutional landscape and can thus inform national policy development. More accurate and comprehensive analyses of the existence of trade mispricing will pave the way for more targeted responses in the fight against illicit financial flows.

2. Background: Peruvian Mining Sector

The Republic of Peru (Peru hereafter) is a resource-rich developing country, and one of the fastest-growing economies in Latin America with an average growth rate of 6% (World Bank, 2019). Peru enjoys a vast natural resource wealth, with huge mineral deposits, hydrobiological resources and a biodiversity considered one of the most important in the world. Given its geological conditions, Peru has developed a mining industry that represents one of the major pillars of the economy, driving domestic economic growth through job generation (direct and indirect), production and infrastructure development, the attraction of private investments, and the collection of fiscal revenues. Overall, the sector contributes up to 13.9% to the country's GDP and up to 62% to the total value of Peruvian exports, distributed between metallic and nonmetallic mining products (Ministerio de Energía y Minas, 2018). From this, metallic mining alone makes 9.8% of the industry's GDP contribution and its products represent 60.6% of the export values. In 2018, Peru ranked second place in the production and export of copper, silver and zinc worldwide, and in Latin America, it is the leading producer of gold, zinc, lead and tin (Ministerio de Energía y Minas, 2018).

Among the main exported metals, copper makes the largest contribution to Peruvian exports, representing 30.7% of the total exported value (Ministerio de Energía y Minas, 2017). Figure 1 shows the yearly evolution of the national production of copper from 2003 to 2018. Overall, the production of copper has consistently increased over the years. In 2003, production reached 845 thousand metric tonnes and by 2017, production reached an annual record of 2.45 million tonnes (Ministerio de Energía y Minas, 2018). This represents 11.42% of the world's copper production and supposes an increase in production of 64.8% with respect to 2003.

Figure 1. Peruvian copper production by year, 2003-2018



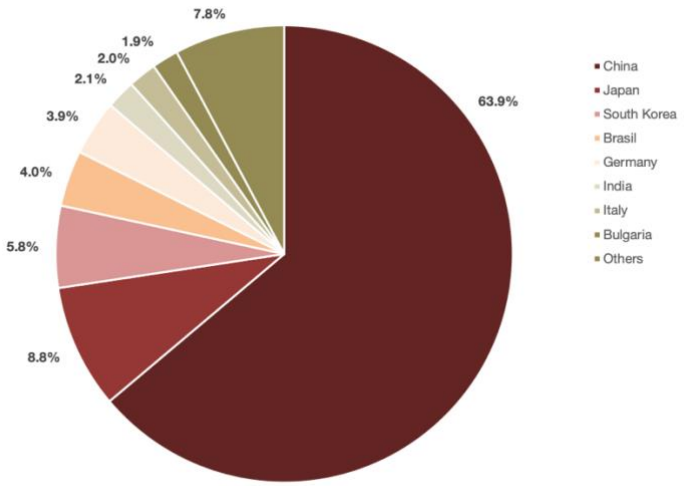
Data Source: Ministerio de Energía y Minas (2008, 2017, 2018)

The increase in production can be explained with the increase in the world's de- mand for copper. This development has been specially driven by China, however the native metal is used and traded worldwide across sectors since 8000 BC. In relation, there has been a considerable growth on investments to develop new mining projects and technologies as well as to expand current infrastructure capacity (BBVA Research, 2017). New mines built between 2011 and 2014, such as Las Bambas, Cerro Verde and Toromocho, started operating between 2015 - 2017, driving the overall production to new levels. For the period 2019-2020, it is forecasted that total investments

will reach US$ 9.8 billion, used to cover pending new as well as current expansion projects approved in the mining portfolio (a total of 31 projects). Again, it is expected that these investments will be reflected in an increased pro- duction for the years to follow.

Subsequently, the value of copper exports has significantly increased from US$ 7.6 billion in 2008 to reach US$ 14.9 billion in 2018 (Ministerio de Energía y Minas, 2018). The value of exports is directly related to the fluctuation of copper prices. In 2018, the main export destinations were China (63.9%), Japan (8.8%) and South Korea (5.8%). Exports to China alone were valued at US$ 9.5 billion (Ministerio de Energía y Minas, 2018).

Figure 2. Main destinations of Peruvian copper exports, 2018



Data source: Ministerio de Energía y Minas (2018)

The principal producers of Peruvian copper have changed over the years. In 2003, the largest producer was Southern Copper Corporation[5] (44%), followed by mining company Antamina S.A.[6] (32%), mining society Cerro Verde S.A.A.[7] (10%) and Xstrata Tintaya S.A[8] (6%). These four companies alone drove 93% of the national copper production (Ministerio de Energía y Minas., 2008). By 2018, Cerro Verde (20%) had already become the largest producer of Peruvian copper, followed by Antamina (19%), mining society Las Bambas S.A.[9] (16%), Southern Peru (14%), and Chinalco Peru (9%). Together, they account for 77.1% of the total copper production.

5 Southern Copper Corporation (listed in NYSE) was founded in 1952 with operations (mining, smelting and refining) in southern Peru and northern Mexico. Peruvian operations include the Cuajone and Toquepala mines. The Peruvian branch is registered as a subsidiary Southern Copper Corporation USA. In 2018, the company declared sales for US$ 7.1 billion and net revenues for US$ 1.54 billion.

6 Antamina's mine is located in the Andes and is operated as a Peruvian company and independent asset. It started production in 2001. Their major shareholders include Australian BHP Billiton (33.75%), Swiss Glencore (33.75%), Teck (22.5%) and Mitsubishi (10%)

7 Cerro Verde is one of the largest Peruvian mining firms, with a mine that holds the largest copper reserves in the country and is one of the world's largest copper operators. Cerro Verde is located in Arequipa. Its parent company is Freeport-McMoRan, a mining company based in Arizona and other shareholders include Sumitomo Metal Mining (21%) and the Peruvian Buenaventura (19%)

8 Tintaya is a Peruvian mine founded in 1980 and located in Cusco region. Since 2006, Tintaya belongs to the Swiss corporation Xstrata (merged in 2013 with Glencore).

9 Las Bambas is a copper mine located in Apurimac region that started operations in 2015. The mining project was initially owned by Glencore Xstrata and in 2014 sold for US$ 5,850 to the Chinese consortium Minerals and Metals Group (MMG). According to MMG, Las Bambas is one of the world's largest copper mines, with an annual nameplate throughput capacity of 51.1 million tonnes. Its operations have been continuously stopped due to social conflicts in the region.

The production and export magnitudes make the mining industry an important source of national tax revenue. In 2003, total contributions to national tax revenues were at 15%, and reached its highest value of 49% in 2007 (Instituto Peruano de Economia, 2011). Currently, they amount to 20% of the overall tax revenues for 2018. Contributions to the tax authorities come in form of taxes and royalties and are collected mainly through an income tax law at a rate of 30% (pretax) and, more importantly, through the Tax on General Sales (IGV), which applies a rate of 18% over sales prices (Del Valle, 2013). Important tax returns apply for investments on exploration studies, infrastructure as public service, or asset purchases and are applicable once mining operations have started. These deductions are quite significant and its effects leading to the erosion of the tax base (e.g. in 2015 there were negative tax contributions) have been already highlighted (CEPAL, 2016). Additional contributions are collected through royalties and mines' rights of use. Royalties are paid by mining concessions for their use of State property and exploitation of natural resources at a rate from 1-12% on operating profit. Rights of use are paid annually based on the hectares used by the concession. Since 2011, the Peruvian government added an additional tax burden on the mining industry through a special tax and levy. Additionally, Peru has developed transfer pricing regulations that apply for related companies. Ultimately, the trading of copper it is considered a free market activity and thus it is not controlled directly by the Peruvian government. Instead firms follow international commercial practices and standards.

Existing studies of illicit financial flows have estimated different magnitudes for Peruvian commodity exports. In its 2019 report, the Global Financial Institute estimated that Peru potentially lost US$ 1.9 billion out of the US$ 34 billions of total trade with advanced countries for the year 2015. The study uses the partner-country methodology and presents comparative results based on the Direction of Trade Statistics dataset (DOTS) dataset from the International Monetary Fund (IMF) as well as the United Nations International Trade Statistics Database (UN Comtrade). However, such aggregated estimates do not provide an understanding of where the outflows are coming from and which commodities or industries are affected.

The Economic Commission for Latin America and the Caribbean (CEPAL) study on commodity exports in Andean countries presented disaggregated estimates for selected commodities for the years 2006 to 2016 (CEPAL, 2016). For the analysis, the study uses the price filter methodology based on export customs data from the Penta-Transaction dataset and the market price data from UNCTAD. However, due to the lack of detailed information on the composition of the concentrates, the study defines the price filters as three scenarios based on assumed concentration levels for a grade 20%, grade 25% and grade 30%, instead of price filters around a benchmark price that can consider for other effects from market conditions or business practices. For a 25% copper grade, the study estimates mispriced capital outflows for Peruvian copper concentrates (HS6 260300) to have increased along the years from US$ 10 million in 2006, to US$ 93 million in 2014, to US$ 121 million in 2016 – up to a total of US$ 662 million for the entire study period (1.1% of the total exported FOB value). In turn, capital outflows for Peruvian refined copper (HS6 740311) are estimated to have reached US$ 64 million (0.3% of the total exported FOB value) for the entire study period. Given the data limitations, the study refrained to describe all data discrepancies as illicit financial flows, instead it emphasizes that certain identified transactions might present atypical prices due to legal commercial reasons and not capital outflows.

3. Empirical Methodology

3.1 Research design

This study conducts a quantitative analysis of abnormal pricing in the export of Peruvian copper concentrate using the LME daily price series as free market price filter. Concretely, the analysis aims at identifying potential mispriced transactions by looking for substantial deviations between the unitary price per tonne of each declared copper transaction and its contemporary reference free market price. Following the price filter methodology with free market prices[10], the analysis assumes a plus/minus range of deviation, that represents the arm's length price range, to account for product characteristics, commercial terms and others known factors.

Based on Hong et al. (2014), and as used in CEPAL (2016) and Carbonnier and Mehrotra (2019), the abnormally over-/undervalued amounts can be identified as deviations from the upper/lower bound of range, as:

$$\textbf{Overvalued amount} = \textbf{volume} * \textbf{MAX}(0, P - P_{High})$$

$$\textbf{Undervalued amount} = \textbf{volume} * \textbf{MAX}(0, P_{Low} - P)$$

where $\mathbf{P}$ is the declared unitary price, $\mathbf{P_{High}}$ is the higher bound of the free market price range and $\mathbf{P_{Low}}$ is the lower bound of the free market price range. Transaction prices that fall within the determined price range are assessed to be normally price, whereas prices that fall outside the range are identified as abnormally priced transactions.

Data for the quantitative analysis comes from two sources:

1. **Transactional-level data** is based on trade statistics from the records of the the Peruvian governmental tax and customs authority (SUNAT). Based on the HS 6-digit classification[11], copper concentrate exports are classified under the tariff heading number 2603000000 'Minerales de cobre y sus concentrados', which includes both copper ore and copper concentrate.

2. The **free market price data** to determine the arm's length price range for Peruvian copper is accessed through the Datastream platform by Thomson Reuters. The specific commodity exchange is the London Metals Exchange (LME) used for both LME-Copper Grade A Cash U$/MT and LME-Copper Grade A 3 Months U$/MT with daily frequency.

The sample is limited to the years 2003-2017 (inclusive), to include the price fluctuations during the years of the copper super cycle, the drop-in prices during the financial crisis and more contemporary developments.

Additionally, the research is supported by qualitative data collected from in-depth interviews with key stakeholders and representatives of the Peruvian copper sector, including large and

[10] Review Appendix A.1 for an overview on the existing methodologies

[11] The Harmonized Commodity Description and Coding Systems (HS) is an international coding system that classifies traded goods on a common basis. The first two digits classify the goods, the next two (HS-4) identify groupings within that good and the last two (HS-6) provide specific information.

small mining companies, traders, government entities and legal and consulting firms. The information gained allows to better understand commercial practices and country-specific customs procedures and therefore inform the selection of the relevant price filters that define the range of acceptable transactions.

Face-to-face semi-structured interviews were conducted in Lima and Arequipa, Peru between 01 April and 29 April 2019. From the governmental side, interviews included the Ministerio de Energía y Minas (MINEM) and the Organismo Supervisor de la Inversión en Energía y Minería (OSINERGMIN). From the business side, interviews included four mining firms that produce and/or export copper concentrate both at a large and smaller scale – such as Compañia de Minas Buenaventura S.A.A and Sociedad Minera Cerro Verde S.A.A[12] – as well as a trading companies. Other interviews included consulting and law firms, such as the Estudio Rubio Leguia Norman (law firm with a strong mining expertise), BDO Peru Tax and Legal Consulting as well as individual consultants. Despite having a good representation of the different sector stakeholders, the interviews missed the participation of two relevant actors, namely the SUNAT and a testing laboratory that analyses export samples. In both cases, data was collected through their official sites. Additionally, as in most cases the interviews included high level representatives of each firms, the risk of obtaining a biased narrative was mitigated by cross-checking the information and reviewing further documents shown during those interviews.

3.2 Data analysis

The compiled dataset comprised 11'640 observations (transactions) with 37 variables for each transaction. The preparation of the dataset for the analysis was done in three steps.

Cleaning the data: The database was carefully reviewed to ensure that only valid commercial transactions for copper concentrate were included in the analysis. This process involved filtering and reviewing the data in layers to detect all irrelevant transactions. These include, for example, shipments of copper ore (included in the customs classification 260300)[13] or related products and test samples with no commercial value.

Standardizing the data: The dataset provided additional transactional information worth retrieving for further analysis. Mainly:

- Grade: refers to the copper concentrate grade, given mostly as a percentage of copper (CU) but also in kilos.
- Byproducts: refers to the byproducts in the concentrate, given mostly by their element symbol. Included: gold (AU), silver (AG), lead (PB), zinc (ZN), molybdenum (MO), cadmium (CD), bismuth (BI), mercury (HG), antimony (SB), arsenic (AS), iron (FE), fluorine (F), magnesium (MG)

12 Although not a leader in copper production, Buenaventura is one of the most important mining firms in Peru and the largest producer of silver, the second largest producer of lead and the fifth largest producer of gold (Ministerio de Energía y Minas, 2017) Cerro Verde is Peru's largest copper and molybdenum producer since 2015. In 2017, the firm produced a total of 501,815 metric tonnes (TMF) which represented 20% of the year's national copper production (Ministerio de Energía y Minas, 2017).

13 Per definition, copper ore is the rock or mineral as extracted from the mine that has a metal content between 0.5 – 2% depending on what the firm considers as commercially valuable (e.g. Southern Peru processes ore with a copper grade over 0.3%). The ore also contains amounts of other metals. and impurities vary from mine to mine. This ore will be later processed and trans- formed into copper concentrate and ultimately transported to metal refineries to be purified.

- Moisture: refers to the humidity level of the concentrate, given usually as a percentage or as total humid metric tonnes (TMH)
- Quality: refers to the type of copper concentrate, which variates according to each mine. Included types: Alyssa, Andaychagua, Cajamarca, Chungar, Colquisiri, Cormin Blend, Goldfield, Huaron, Quiruvilca, GP 37 17 16 31
- Packaging: refers to how the concentrate is being transported. Included: in super sacs, in big bags, in containers, in bulk, in pallet

As shown in table 1, the information was scattered and not consistently found across the database. It isn't until year 2013 onwards that information about the concentration grade, byproducts and humidity levels starts to be consistently included in the database. Overall, 44% of all observations had a relevant indication.

Table 1

Availability of additional information, by year

Year	Transactions*	Added Info**	%**	Relevant***	%***
2003	104	78	75%	-	-
2004	164	17	10%	-	-
2005	171	10	6%	-	-
2006	198	61	31%	-	-
2007	431	294	68%	-	-
2008	698	494	71%	-	-
2009	776	602	78%	-	-
2010	706	587	83%	28	4%
2011	780	568	73%	5	1%
2012	1014	751	74%	3	0%
2013	1331	915	69%	520	39%
2014	1015	823	81%	344	34%
2015	1094	888	81%	544	50%
2016	1107	965	87%	745	67%
2017	1155	1116	97%	1094	95%

*Total observations per year

**From year total, how many observations have additional information

***From those with additional information, how many include information relevant for the analysis i.e. grade and byproducts

Because the data had been added in an irregular way that can be attributed to human recording error (variables were separated using different characters, included multiple grammar mistakes, or were incomplete), the data was manually standardized across the database to avoid risking losing accuracy.

Matching databases: The customs and the price database were merged based on the transaction date to compare declared prices with free market prices.

3.3 Price composition of copper concentrate

Understanding the price composition of copper concentrate is required to later select the relevant price filters. The qualitative interviews helped outline the four key components that determine the final export value, namely quantity, quality, price and commercial terms. Figure 3 shows how the four components in the commercial invoice add up to the final value of the cargo, further declared as FOB value in the customs form.

Figure 3. Sample of a commercial invoice

Commercial Invoice

weight	Final wet weight		33.220 wmt				
	Final moisture	9.0%	2.990 mt				
	Final dry weight		30.230 dmt				
	Weight franchise	0.5%	0.151 mt				
	Final net dry weight		30.079 dmt				
payable elements		Content/Assay	Payment Terms	Net payable		Reference Price	Total/Element
	Copper (Cu)	21.110%	1.30%	19.81%	19.81%	$6'235.00	$1'235.15
	Silver (Ag)	25.371 grms	-50 grms	0.00 grms	0.000 ozs	$15.00	$0.00
	Gold (Au)	8.229 grms	-1.5 grams	6.792 grms	0.216 ozs	$1'280.60	$276.99
						Total Payables	**$1'512.14**
charges	Treatment charge TC						**-$135.00**
	Refining Charge RC						
	Copper	$0.135	per payable ozs	0.1981	net payable		**-$58.96**
	Silver	$0.50	per payable ozs	0.0000	ozs		**$0.00**
	Gold	$9.00	per payable ozs	0.2163	ozs		**-$1.95**
penalties		Content	Accepted	Final content	$	per each	
	Arsenic (As)	0.50 %	0.25 %	0.25%	$2.00	0.10%	**-$11.00**
	Antymony (Sb)	1.00 %	0.10 %	0.90%	$2.00	0.10%	**-$18.00**
	Bismuth (Bi)	9000	700	8300	$2.00	100	**-$1.60**
	Zinc (Zn) + Lead (Pb)	0.12 %	5.00 %	0.00%	$2.00	1.00%	**$0.00**
						Total Deductibles	**-$226.51**
	Freight Allowance to seller (per wmt)		$27.12				**$29.80**
						Final value per metric ton	**$1'315.44**
						Final value cargo	**$39'567.01**

Note: This sample invoice does not belong to one particular company but is based on diverse material gained on the interviews.

Quantity. Copper concentrates contain a level of moisture, thus weight differentiates between wet metric tonnes (wmt) and dry metric tonnes (dmt). The price is applied on dmt. The weight and moisture analysis[14] is done at the time of boarding by independent firms who issue a weight certificate. The results determine the values used in the commercial invoice and are attached to the customs declaration form and bill of lading. Depending on the contracts, a weight franchise of 0.5% might be applied on the dry weight, resulting on a final net dry weight.

Quality. The quality of the copper concentrate is determined by the concentrate grade and the type and content of the byproducts. Grades can vary across each mine, usually fluctuating between 20-30%. Additionally, concentrates contain di- verse byproducts, considered payables or penalties. Due to economic and environ- mental reasons, the byproducts are usually processed. Standard payable byproducts are gold and silver. Other byproducts, e.g. arsenic, bismuth or lead, are considered as penalties that compensate the smelter[15] depending on their content.

Price. Price is mostly based on the LME spot, however the purchase-sale contracts determine a quotation period, for example by taking the average market price of the month the cargo arrived at its destination port or 3 months after the month of arrival (3 MAMA).

[14] There is a transportable moisture limit (tml) to ensure a cargo does not liquefy while in transit

[15] E.g. due to processing or disposal difficulties, many smelters or refineries do not accept arsenic levels >0.5wt%

Commercial terms. Typical industry contracts determine the payable copper terms that are established to account for product losses in the refining process[16]. This means that not the entire value of the concentrate is paid, but payments usually deviate between 96.5% and 96.75% depending on the copper content[17]. Lower grades are usually subject to a minimum deduction of 1.0 unit applied on the grade to compensate smelters. The same concept applies to the payable byproducts. Terms specify the payment and the minimum threshold byproducts must have in order to be payable[18]. Further deductions are included in form of the Treatment Charge (TC), given in US$/dmt and the Refining Charge (RC), given in US ct/lb based on the copper content and byproducts in the concentrate. Known as TC/RC, they represent the cost of the smelter to convert a tonne of concentrates into metal. Other contractual terms can be freight allowances, which provide a dis- count on freight to the seller.

Accordingly, the final value is determined by the following equations[19].

I. The value of the payable elements is calculated as:

$$\text{Value concentrate} = (CU_{Grade} - D) * P_m$$

where $\mathbf{CU_{Grade}}$ is the copper grade, $\mathbf{D}$ are the deductions and $\mathbf{P_m}$ is the reference price. And:

$$\text{Value byproducts i} = (B_i - D_{Bi}) * P_{mbi}$$

where $\mathbf{B_i}$ is the content of the byproducts *i*, $\mathbf{D_B}$ are the deductions applied to each and $\mathbf{P_{mb}}$ the reference price.

Both equating to:

$$\text{Payables} = \text{value concentrate} + \text{value byproducts}$$

II. Deductions are calculated as:

$$\text{Deductions} = TC + RC_{CU} + RC_{BPi}$$

where $\mathbf{TC}$ is the treatment charge, $\mathbf{RC_{CU}}$ is the refinery charge for copper concentrate and $\mathbf{RC_{BP}}$ are the refinery charges for the byproducts i.

III. Further deductions for penalizable elements are calculated as:

$$\text{Penalties} = PE_i * P_i$$

where $\mathbf{PE_i}$ is the content of penalizable elements *i* and $\mathbf{P_i}$ is the price to process them.

16 Despite optimization in the refining, it is not possible to recover the product to a 100 percent

17 As a general rule, the higher the grade, the higher the payment

18 For example, a gold content <1 gr/dmt or silver content <30 gr/dmt might be considered as non payable

19 Review CEPAL (2016) for a similar breakdown

IV. The final net weight is calculated as:

$$\text{Final weight in dmt} = \text{wmt} - (\text{wmt} * h) - w_f$$

where **wmt** is wet metric tonnes, **h** is moisture level, and $\mathbf{w_f}$ is an applicable weight franchise

V. The final value is then composed as:

$$\text{Final value} = \text{dmt} * (\text{Payables} - \text{Deductions} - \text{Penalties})$$

Such detailed information on the composition of the concentrate is usually not included in the customs declarations. Given the information available in the used database, the calculations in this analysis were done in two forms. First, the unitary price for all transactions was calculated as:

$$\text{Unitary price} = \text{FOB value/net weight}^{20}$$

The hypothesis to test is:

Hypothesis: When the grade of the copper concentrate and byproducts are not considered in calculating the unitary price of the transactions, the analysis will result in transaction prices which strongly fall outside the defined arm's length price range of the free market price, namely strong undervalued transactions.

For transactions that indicated the copper grade, the estimated used market price is calculated as:

$$\text{Graded LME price} = (CU_{grade} * P_m)$$

Following, the FOB value is estimated as:

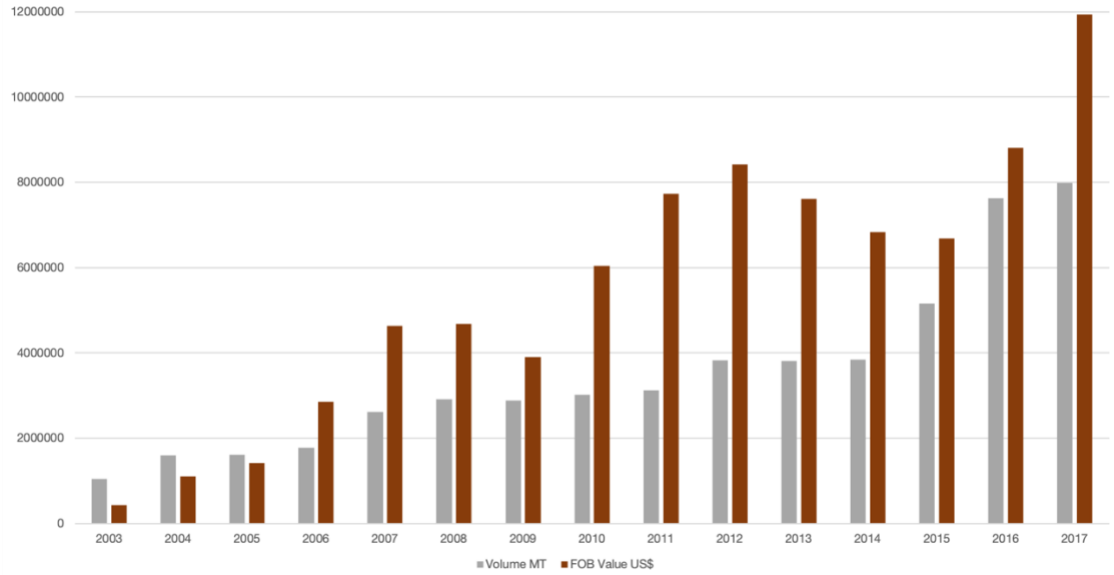
$$\text{Estimated FOB value} = (CU_{grade} * P_m) * \text{net weight}$$

20 converted to tonnes

4. Empirical Findings

Peruvian customs data indicates that between 2003-2017, the total value of copper ore and concentrates (HS 260300) exports increased by an average of 34% per year. In 2017, Peru exported almost 8 times the volume exported in 2003, reaching a total of 7'992'989 metric tonnes. Figure 4.1 plots the yearly export values and volumes of copper concentrate.

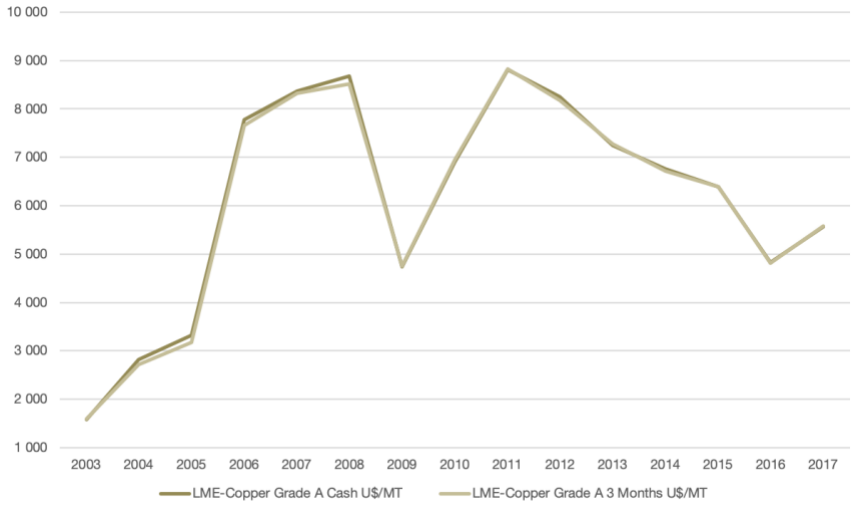
Figure 4.1. Peruvian exports of copper concentrate (HS2603), 2013-2017



N=10,474; Data Source: SUNAT; Note: Volume is calculate in metric tonnes and FOB value in thousand US$.

The growth in exports is a result not only of an increase in production capacity and exported volumes but can be further understood by looking at the evolution of the LME free market price for copper. Figure 4.2 shows that after the 2008 sharp decline in prices, as a result of the economic and financial crisis, prices started to recover reaching a maximal value of 10'1478 US$/MT in the first quarter of 2011. The price fluctuations are reflected in the exported volumes as well as in the increased FOB values of exports in Figure 4.1.

Figure 4.2. Evolution of free market prices LME Copper Grade A, 2013-2017

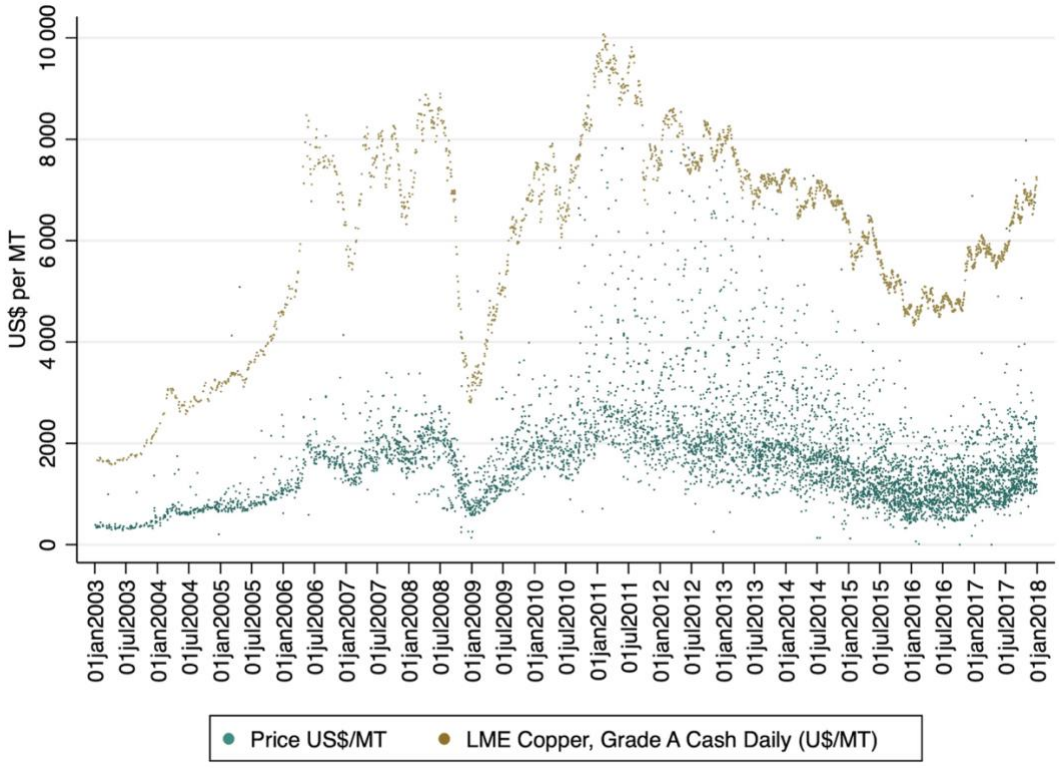


Data Source: Thomson Reuters Datastream

4.1 Initial estimates of abnormal pricing

Figure 4.3 presents a scatterplot of the transaction prices in US$ per metric tonne compared to the free market benchmark price used to determine the arm's length price range, the LME's daily price series. The mean unitary price lies at US$ 1941.74. The summary statistics can be found in the Appendix A.2.

Figure 4.3. Transaction prices vs market reference prices, 2003-2017



N=10,620; Data Source: SUNAT, Thomson Reuters Datastream

These initial results would suggest that a significant proportion of Peruvian copper concentrate exports are abnormally undervalued. Nevertheless, as informed a priori by the qualitative research, the calculated unitary prices without correction for grade are expected to deviate considerably from the benchmark price. I conduct a price filter analysis to further illustrate this observation. The filters selected to determine the magnitude of normal deviations around the LME benchmark price are based on assumptions derived by qualitative research according to the following criteria:

- **Copper content**: The LME benchmark price for copper is based on refined copper, whereas concentrates contain different grades of copper, along with other metals. The quality of both the copper and the other metals within the concentrate vary from mine to mine. The available information on copper grade taken from the customs database, shows a mean grade of 24.77% (for n=2121 observations), with most transactions featuring between 18.9% - 33.14%. The grade, which is used to calculate the transaction price, has a negative impact on the observed transaction prices. I must assume a potential negative deviation of up to 80% from the benchmark price.

- **Payable byproducts**: In addition to copper, concentrates are composed by other metals, such as silver and gold, that can be extracted and utilized. These additional metals add value to the concentrate and thus have a positive impact on the observed transaction prices. The payable

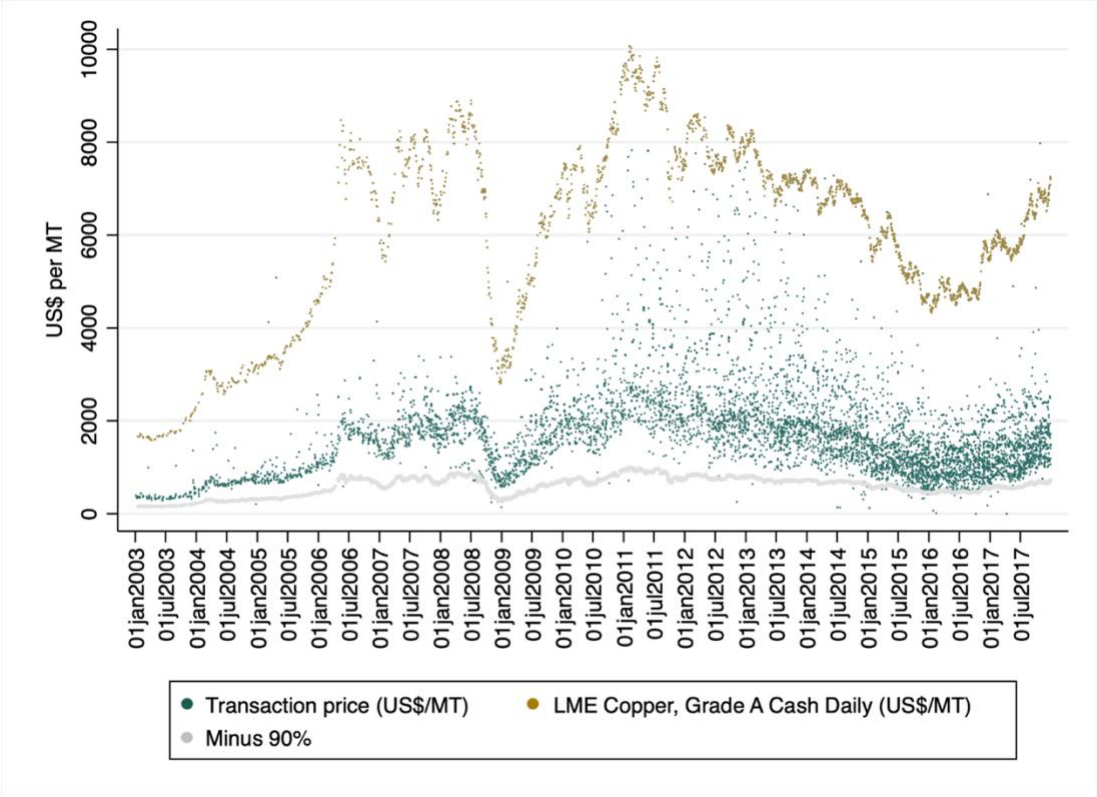
byproducts are also subject to payment terms. Following my calculations from the commercial invoices I accessed, I assume a positive margin of 10% around the benchmark price.

- **Penalties**: Other elements contained in the concentrate that are considered as impurities reduce the overall value of the concentrate. Again, based on my calculations derived from the accessed invoices, I assume a negative margin of 5% to account for the negative impact that penalizable elements have on the transaction price.

- **Commercial terms**: In contrast to the less significant freight allowances to the seller, deductions such as payment terms or TC/RCs are expected to have a negative impact on the observed transaction price. Payment terms are established in the contracts and TC/RCs tend to follow the benchmark annual terms established between the world's major mines and smelters and published usually by year-end. They are based on the contents of the concentrate and deduced from the total payable. Although as a market-driven commercial term they variate according to the market copper price, I assume a conservative margin of 12% below the benchmark unit price.

Taking into consideration all these factors, I assume an arm's length price range of 90% below the benchmark price. Solely by being a concentrate instead of a refined product, concentrate exports will show a lower value than exports of refined copper. The added value of the payable products is somewhat cancelled out by the additional deductions applied on the final price. If the weight of the payable byproducts were to be considerably high, and thus raising the final value of the concentrate, then they might be better considered under another export category. This is why the analysis considers only the filter in the negative direction. Figure 4.4 adds the selected price filter to the scatterplot.

Figure 4.4. Transaction prices vs market reference prices, filter 90%, 2003-2017



N=10,620; Data Source: SUNAT, Thomson Reuters Datastream. Transactions (N = 3,249) without a free market daily price assigned due to differed date were assigned the latest available price.

The results from the free-market price filter analysis show no significant indications of abnormal undervalued exports. The estimates for undervalued exports are reported in Table 4.1. Abnormal pricing estimates for different filters as a sensitivity analysis are also presented.

The estimated magnitude of undervalued exports for the period 2003-2017 reached merely US$ 67 million, which equals to 0.1% of the total export value. Section 5 discusses the validity of such a high filter and the results from the sensitivity analysis, which show the impact of the assumptions taken for estimating abnormal pricing transactions. Moreover, I discuss the potential driving factors behind the estimates. In any case, these first results cannot be taken at face value as final estimates of abnormal pricing and furthermore of illicit outflows. Instead, the results prove that in the case of concentrates, the measures must be adapted to account for the complexity of the data, i.e. the composition of the exported copper.

Table 4.1.
Undervalued exports of Peruvian copper concentrate in US$ (per million), 2003-2017

Year	Export Value	Free Market Price Filter **Minus 50%**	%	Free Market Price Filter **Minus 70%**	Free Market Price Filter **Minus 80%**	Free Market Price Filter **Minus 90%**	%
2003	426'327	394'408	93%	379'612	99'508	-	0
2004	1'097'426	1'084'022	99%	1'058'773	33'586	1'033	0.1%
2005	1'418'586	1'410'586	99%	1'265'262	18'626	-	0%
2006	2'859'196	2'854'400	100%	2'743'771	87'008	1'480	0.1%
2007	4'628'712	4'625'224	100%	4'258'193	240'217	0	0%
2008	4'680'539	4'676'310	100%	4'302'686	481'592	53'729	1.1%
2009	3'899'936	3'803'820	98%	2'953'301	359'061	32	0%
2010	6'047'812	5'944'944	98%	4'437'413	416'825	64	0%
2011	7'725'145	7'317'273	95%	5'063'928	353'065	83	0%
2012	8'422'750	7'736'500	92%	5'999'376	577'886	61	0%
2013	7'609'850	7'392'098	97&	5'387'817	314'958	-	0%
2014	6'839'031	6'766'218	99%	4'866'794	891'784	2'719	0%
2015	6'682'209	6'678'495	100%	4'732'976	1'520'909	7'147	0.1%
2016	8'812'530	8'806'711	100%	6'103'331	2'557'168	712	0%
2017	11'934'985	11'902'934	100%	8'416'995	3'590'369	255	0%
Total	**83'085'033**	**81'393'942**	98%	**61'970'228**	**11'542'562**	**67'317**	0.1%

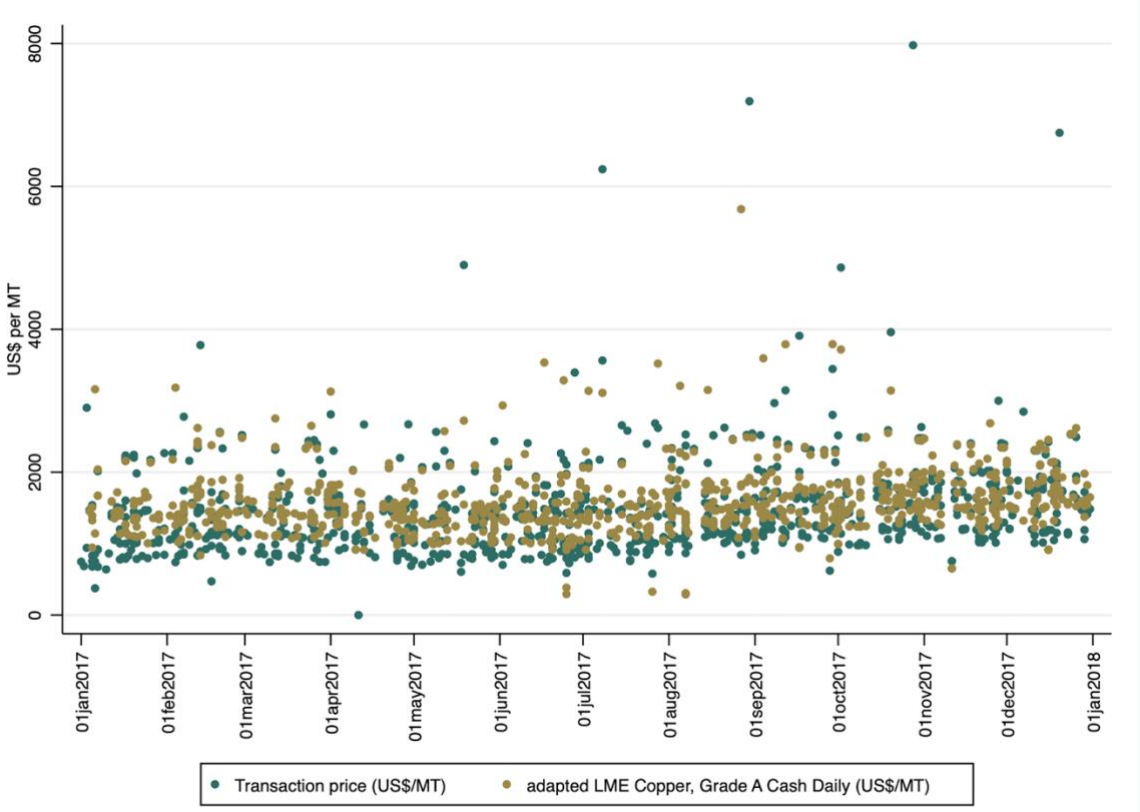
Notes. N=10,620; Data Source: SUNAT for HS 2603 for period 2003-17. Free-market price is daily LME Copper, Grade A (US$ per metric ton)

4.2 An in-depth analysis of mispriced transactions

The effect of the copper grade on the unitary price per tonne is considerable. A more precise way to measure the existence of abnormal mispricing in the case of concentrates is to include the key characteristics of its composition. To show the value added of such an approach, I additionally conduct an analysis of the export transactions for 2017, where I have an indication of the grade in 95% of the observations. The mean grade for the observations lies at 25.58% (for N=1084).

Figure 4.5 presents a scatterplot of the transaction prices in US$ per metric tonne compared to the 2017 LME daily benchmark price series that have been adapted to the declared grade (see Section 3.4 for a review). Overall, the transaction prices lay considerably closer to the benchmark price than in Figure 4.4.

Figure 4.5. Transaction prices vs 'graded' market reference prices, 2017



N=1084; Data Source: SUNAT, Thomson Reuters Datastream

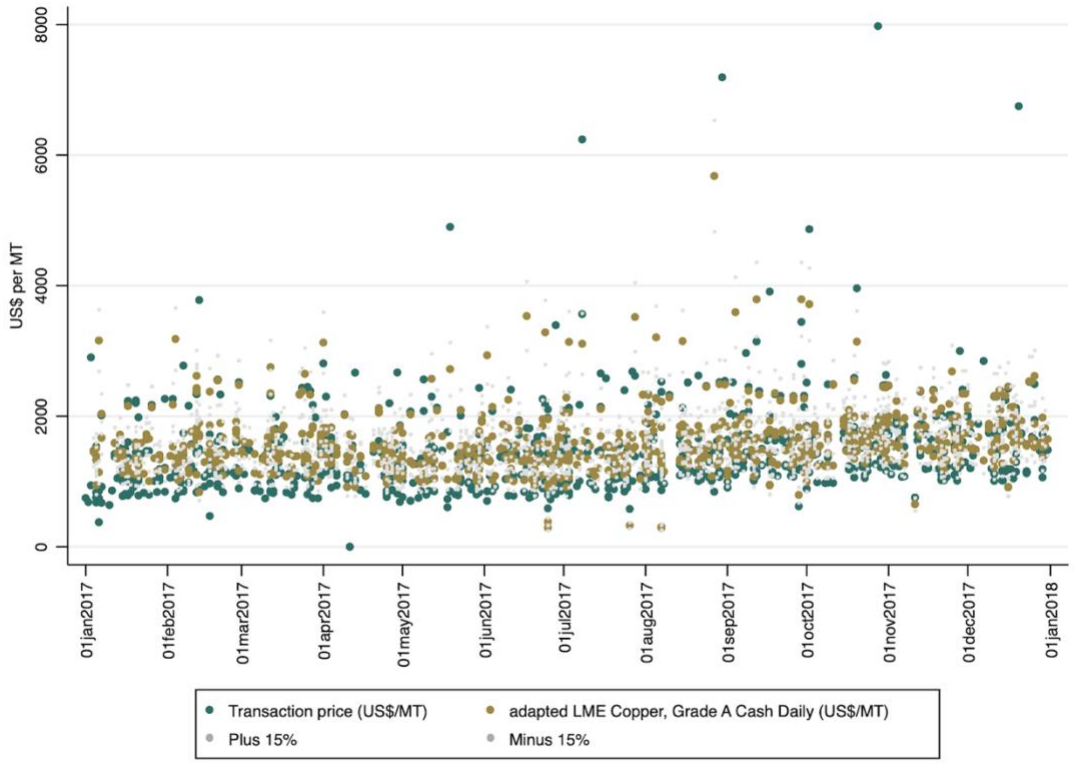
In the following, I adapt the relevant price filters according to the following criteria as informed by qualitative research:

- **Byproducts:** Payable metals present in the concentrate, such as silver and gold, add value to the price of the concentrate. However, this effect is partly cancelled out by impurities or undesired elements to which penalizations are applied. As a result, I assume a positive margin of 5% around the benchmark price.

- **Commercial terms:** Payment terms and further deductions such as TC/RCs must still be considered for their negative impact on the observed transaction prices. I assume a conservative margin of 12% below the benchmark unit price.

Based on these factors, I assume a conservative arm's length price range of free market prices plus and minus 15% as the baseline estimate. Figure 4.6 plots the transaction prices in US$ compared to the daily benchmark price series and the selected price filter.

Figure 4.6. Transaction prices vs 'graded' market reference prices, 2017



N=1084; Data Source: SUNAT, Thomson Reuters Datastream

The resulting estimations from the free-market price filter analysis for the year 2017 are reported in Table 4.2. The estimated magnitude of undervalued exports of Peruvian copper concentrate is US$ 3.8 billion, which represent 32% of the total export value. This implies that a significant amount of transactions are abnormally undervalued. Interestingly, the average deviation between the unitary price and the market price for all these transactions was -23%. Section 5 discusses the potential driving factors behind the estimates and the accuracy of the selected filters.

Table 4.2
Mispriced exports of Peruvian copper concentrate in US$, (per million), 2017

Export Value	Free Market Price Filter Minus 12%	%	Free Market Price Filter Minus 15%	%	Free Market Price Filter Minus 20%	%	Free Market Price Filter Minus 25%	%
11'934'986	4'368'500	37%	3'831'776	32%	2'694'854	23%	709'257	6%

Although results could be taken at face value as a clear indication of illicit flows, the available information allows a more in-depth analysis of the estimates. A conscious effort of under-invoicing of export transactions might be motivated by an attempt to shift profits to a related company abroad where tax regulations might be more beneficial. Therefore, the results should show substantial differences in the unitary transaction prices when comparing each firms' mispriced transactions between different destinations, ultimately favoring destinations in which the exporting company might have a related partner. Tables 4.3, 4.4 and 4.5 present the results from the price filter analysis for minus 15%, 20% and 25% respectively, disaggregated by exporting firm. The tables include only the first 8 firms whose total mispriced transactions value are the highest for the respective filter. Note that the positioning of the firms in each table is directly related to the magnitude of their exports. Therefore, it is important to consider the share of mispriced transactions vs their total exported values to get a better sense of the magnitude of the undervaluation.

Table 4.3

Undervalued transactions by firm (in US$ million) for price filter minus 15%, 2017

Exporter	Total FOB Value	Mispriced FOB Value	Avg Unitary Price	Avg CU Grade	Avg graded market price
Sociedad Minera Cerro Verde S.A.A	2'407'923	2'394'136 (99%)	1'119.53	23.2%	1'441.28
Brazil		47'631	1125.34	23.3%	1438.52
Bulgaria		58'488	1103.62	23%	1407.42
China		1'212'056	1124.63	23.1%	1447.43
Germany		62'086	1181.17	23.8%	1497.09
India		200'844	1130.72	23.5%	1427.61
Japan		575'103	1091.50	23.4%	1426.09
Republic of Korea		70'196	1119.44	23%	1436.67
Spain		167'729	1106.23	23.2%	1431.02
Minera Chinalco Peru S.A.	490'375	422'732 (86%)	906.87	19%	1'157.94
Belgium		8'945	678.69	17%	943.62
Bulgaria		4'722	830.19	20%	1119.40
China		128'182	921.64	19%	1176.73
Germany		22'727	873.98	19%	1113.73
India		4'645	841.44	18%	1019.53
Republic of Korea		119'661	918.70	19%	1159.76
Malaysia		72'748	931.98	19%	1175.42
Mexico		5'068	684.76		
Oman		12'044	834.94	18%	1105.80
Philippines		16'426	804.96	18%	1030.25
Spain		27'560	820.96	19%	1059.57
Hudbay Peru S.A.C.	566'411	324'258 (57%)	1204.74	25%	1'503.73
Brazil		12'634	1197.57	25%	1415.14
Bulgaria		37'550	1159.54	24%	1440.63
China		149'295	1248.20	25%	1507.42
Germany		12'403	1148.24	24%	1413.29
India		28'047	1298.43	25%	1558.31
Philippines		84'326	1301.32	25%	1576.57
IXM Trading Peru S.A.C.	328'209	179'409 (55%)	1124.86	24%	1'556.64
China		59'307	1404.51	23%	1526.25
Namibia		116'909	984.24	24%	1570.83
Taiwan, Province of China		3'194	713.24		
Compania Minera Antamina S.A.	2'394'282	143'407 (6%)	1552.17	30%	1'993.71
China		114'339	1588.91	30%	1995.45
Germany		14'356	1416.23	27%	1724.73
Japan		14'712	1430.88	27%	1710.47
Compania Minera Antapaccay S.A.	1'233'528	124'927 (10%)	1549.17	32%	1'930.92
Brazil		34'639	1539.51	31%	1820.18
China		18'235	1538.81	39%	2253.43
India		19'907	1679.64	28%	1984.19
Republic of Korea		18'086	1526.12	33%	1872.54
Philippines		34'059	1461.76	28%	1724.24
Glencore Peru S.A.C.	302'780	85'706 (28%)	956.44	21%	1'280.1
Australia		9'832	926.85	22%	1256.24
Canada		2'095	748.89	26%	1450.35
China		68'796	1028.63	21%	1311.56
Mexico		4'983	688.25	18%	1039.31
Sociedad Minera El Brocal S.A.A.	59'651	59'651 (100%)	1065.11	25%	1'598.18
Chile		489	908.86		
Malaysia		26'070	1141.63	26%	1680.29
Mexico		1'030	1096.21	23%	1299.99
Thailand		11'902	972.25	25%	1520.70
Vietnam		20'159	1064.40	25%	1593.39

Table 4.4
Undervalued transactions by firm (in US$ million) for price filter minus 20%, 2017

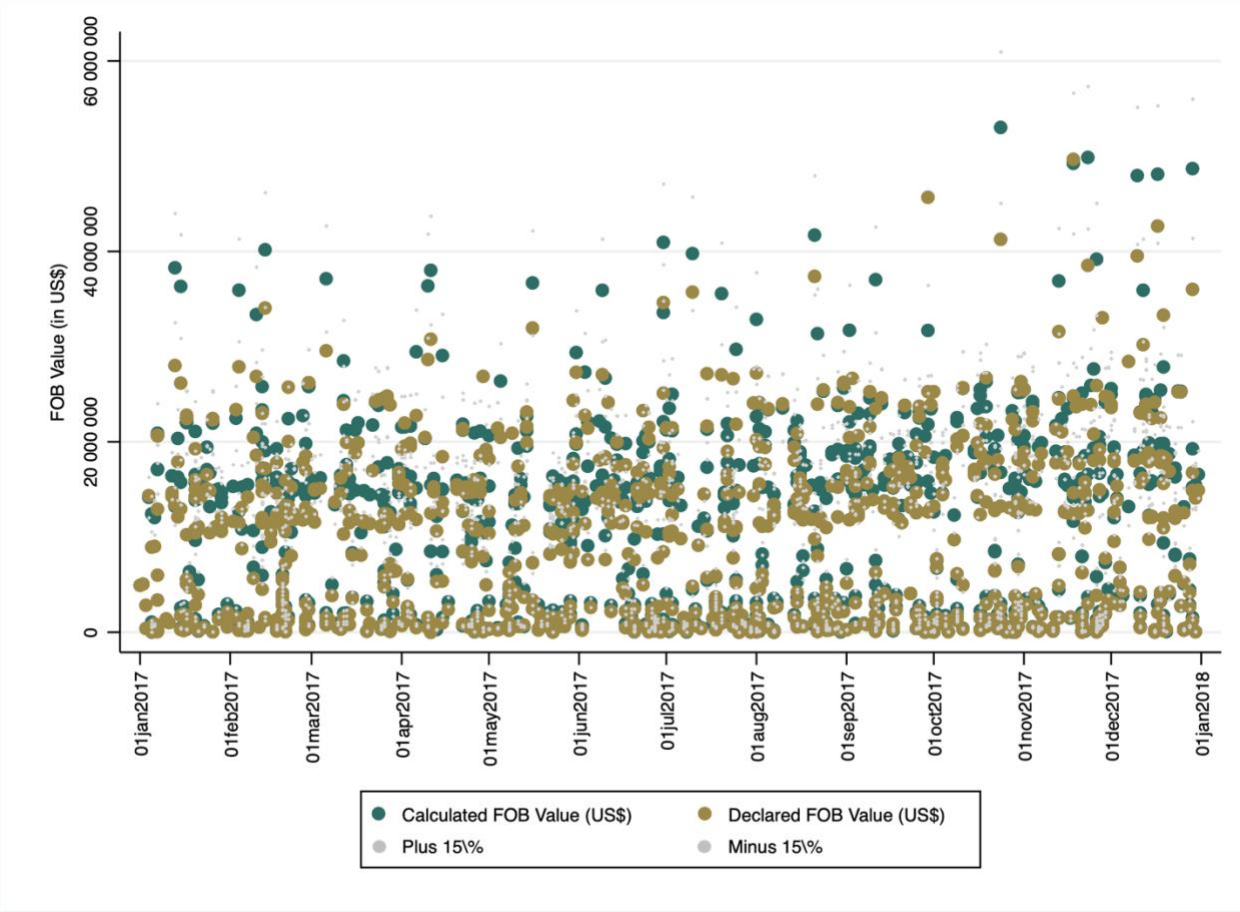
Exporter	Total FOB Value	Mispriced FOB Value	Avg Unitary Price	Avg CU Grade	Avg graded market price
Sociedad Minera Cerro Verde S.A.A	2'407'923	1'942'671 (81%)	1'106.77	23.23%	1'441.55
Brazil		34'767	1'090.17	23.64%	1412.11
Bulgaria		58'488	1103.62	22.98%	1407.42
China		900'833	1104.39	23.12%	1444.38
Germany		62'086	1181.17	23.80%	1497.09
India		155'234	1141.43	23.51%	1458.46
Japan		563'653	1091.36	23.35%	1428.49
Republic of Korea		70'196	1119.44	23.03%	1436.67
Spain		97'410	1080.06	23.25%	1437.58
Minera Chinalco Peru S.A.	490'375	284'657 (58%)	850.29	18.81%	1'121.57
Belgium		8'945	678.69	16.97%	943.62
Bulgaria		4'722	830.19	19.5%	1119.40
China		73'739	862.85	19.02%	1142.1
Germany		12'069	808.84	18.64%	1084.95
India		4'645	841.44	18%	1019.53
Republic of Korea		83'941	834.60	18.5%	1086.16
Malaysia		53'160	906.66	18.8%	1158.99
Mexico		5'068	684.76		
Oman		12'044	834.94	18.18%	1105.80
Philippines		7'633	804.96	18.02%	1041.47
Spain		23'332	824.93	18.65%	1072.87
IXM Trading Peru S.A.C.	328'209	166'368 (51%)	1088.42	24.06%	1'563.96
China		46'265	1493.27	24.83%	1460.94
Namibia		116'908	984.24	24.01%	1570.83
Glencore Peru S.A.C.	302'780	79'413 (26%)	929.58	21.28%	1'248.78
Australia		9'832	926.85	21.57%	1256.24
Canada		2'095	748.89	25.72%	1450.35
China		62'503	1000.37	20.45%	1249
Mexico		4'983	688.25	18.2%	1039.31
Sociedad Minera El Brocal S.A.A.	59'651	57'679 (97%)	1055.84	25.35%	1'590.93
Chile		489	908.86	25.53%	1'664.78
Malaysia		24'098	1'114.57	22.75%	1'299.99
Mexico		1'029	1'096.21	25.32%	1'520.70
Thailand		11'902	972.25	25.4%	1'593.39
Vietnam		20'159	1'064.40		
Compania Minera Antamina S.A.	2'394'282	53'461 (2%)	1729.54	34.84%	2'277.65
China		53'461	1729.54	34.84%	2277.65
Hudbay Peru S.A.C.	566'411	25'137 (4%)	1163.74	24.99%	1'461.82
Bulgaria		12'334	1'142.07	24.2%	1'429.43
China		12'802	1'185.42	25.77%	1'494.21
Trafigura Peru S.A.C.		20'683 (3%)	1'096.97	22%	1'348.84
China		19'861	1'178.76	17%	1'172.28
Spain		821	1'015.17	25%	1'437.12

Table 4.5.
Undervalued transactions by firm (in US$ million) for price filter minus 25%, 2017

Exporter	Total FOB Value	Mispriced FOB Value	Avg Unitary Price	Avg CU Grade	Avg graded market price
Sociedad Minera Cerro Verde S.A.A	2'407'923	434'306 (18%)	1'081.55	22.90%	1'462.82
China		229'983	1'081.05	22.86%	1'462.1
Japan		148'181	1'108.04	22.83%	1'499.97
Spain		56'141	1'023.23	23.36%	1'381.23
IXM Trading Peru S.A.C.	328'209	111'675 (34%)	1011.38	24.06%	1'563.96
China		12'120	1'086.21	24.83%	1460.94
Namibia		99'555	1'006.39	24.01%	1570.83
Minera Chinalco Peru S.A.	490'375	51'289 (10%)	816.16	19.25%	1'126.08
Belgium		8'946	678.69	16.97%	943.62
Bulgaria		4'723	830.19	19.5%	1119.40
China		23'305	818.6	19.38%	1130.55
Germany		3'968	784.77	19.09%	1'093.69
Republic of Korea		10'348	855.54	19.36%	1'177.57
Sociedad Minera El Brocal S.A.A.	59'651	34'854 (58%)	1'066.83	25.39%	1'582.11
Malaysia		15'049	1'130.40	25.23%	1'642.80
Thailand		5'520	895.78	25.43%	1'480.06
Vietnam		14'285	1'106.95	25.49%	1'589.78
Glencore Peru S.A.C.	302'780	25'929 (9%)	804.61	21.50%	1'221.90
Australia		9'832	926.85	21.57%	1256.24
Canada		2'095	748.89	25.72%	1450.35
China		9'019	854.48	20.5%	1'141.70
Mexico		4'983	688.25	18.2%	1039.31
Compania Minera Antapaccay S.A.	1'233'528	18'235 (1%)	1'538.81	38.99%	2'253.43
China		18'235	1'538.81	38.99%	2'253.43
Compania Minera Antamina S.A.	2'394'282	17'397 (1%)	1'688.98	38.56%	2'285.45
China		17'397	1'688.98	38.56%	2'285.45
Minera Yanacocha S.R.L.	13'894	4'933 (36%)	1'578.83	52.57%	3'144.97
Republic of Korea		4'933	1'578.83	52.57%	3'144.97

An additional way to test the robustness of the results is to compare the FOB value as declared in the customs declaration form (Declaración aduanera de mercancías (DAM)) with a calculated FOB value based on the free market price and the copper grade in the concentrate. The results are plotted in Figure 4.7.

Figure 4.7. Declared FOB values vs calculated FOB values, 2017



N=1084; Data Source: SUNAT, Thomson Reuters Datastream

Table 4.6 shows the estimations resulting from the filter analysis. The difference between the declared values and the calculated values in 2017 add up to US$ 3.6 billion, which represents a 31% of the total FOB value. Interestingly, the estimations from the sensitivity analysis resemble the previous estimations.

Table 4.6.
Differences in FOB values (in US$ per million), 2017

Export Value	Filter Minus 15%	%	Filter Minus 20%	%	Filter Minus 25%	%
11'934'986	3'667'292.55	31%	2'530'370.81	21%	709'257.48	6%

5. Discussion

5.1 Behind large estimations of abnormal pricing in copper concentrate

The initial free-market price filter analysis results in significant estimates of ab- normal pricing. The magnitude of undervalued exports variates depending on the filter used around the benchmark price. In all the scenarios presented, the estimates indicate an undervaluation of exports of different significance for all the years analyzed. The selected high price filters are justified by the assumptions derived by qualitative research. These indicate that the price per exported tonne of copper concentrate is composed not only by the copper market price but is strongly influenced by the byproducts in the concentrate and recurrent commercial practices as established by the purchase-sale contracts. The price filter of 90% reflects especially the negative effect the copper grade has on the transaction price. If the copper grade is at 26.1% (which is the average copper concentration for ex- ports in 2017), then the benchmark market price directly explains 26% of the final transaction price. Additionally, the price filter accounts for the negative impact of refining and treatment costs, payment terms and deductions from impurities as well as the positive impact of the payable byproducts. The initial results with a 90% price filter calculate an abnormal undervaluation of merely US$ 67 million, which represent only 0.1% of the total exports between 2003 to 2017, suggesting no significant levels of mispricing in the export of Peruvian copper concentrates. The transactions are destined to Japan, China and India.

However, further reducing the price filter to 80% does result in more significant estimated values of abnormal undervaluation of US$ 11 billion, which represent 14% of the total exports between 2003 to 2017. Here, transactions are destined to China, Japan and the Republic of Korea. In contrast, a further 10% decrease to a 70% price filter estimates that 75% of the all transactions are underpriced. This shows that the reasonable scope in which the price filter can be correctly placed could deviate between 70 to 90%. The results observed in the 80% price filter can be explained by the following:

First, the composition of the copper concentrate varies significantly by source. The recovery and concentration process differs from one mine to another, affecting the moisture, final weight and purity of the concentrate. Impurities (non-payable or recoverable byproducts) result in deductions that can significantly lower the unitary transaction price. Thus, indications of under-valued transactions need to be further analyzed by looking at the composition of the exported concentrate. An identification of the sources of poor-quality copper concentrate can help evaluate the results of undervalued exports.

Additionally, the role that the purchase-sale contracts have in the final transaction prices must not be underestimated. Contracts determine not only the payment terms, but more importantly, the benchmark for payable byproducts as well as the quotation pricing period, both of which have a strong impact on the final value of the export. As such, transactions that are initially considered outside the price filters and thus regarded as “atypical" can be explained through the contract clauses. Nevertheless, this information is not included in the customs declaration forms and thus hard to backtrack by looking only at customs-level export data. Access to contracts between sellers and buyers from different stakeholders can help to further refine the chosen assumptions.

Consequently, the composition of copper concentrate strongly differs from the com- position of the copper Grade A, as defined in the LME benchmark price. Therefore, the unitary price per transaction

as calculated from the declared FOB value can only be expected to negatively differ from the free market price. At the bare minimum, a more accurate analysis must account for the grade of the concentrate to start making estimations of mispricing.

Additionally, although all interviewees confirmed setting their prices based on the LME copper price series, it is possible that further mining companies and traders sell concentrates using another benchmark than the LME. For example, given the importance of the Asian market for Peruvian copper exports, the Shanghai Metals Market (SMM) might also be relevant.

Finally, the customs heading 2603 that includes copper ore and copper concentrates falls short in identifying the type of concentrate exported. The transaction prices of shipments containing a small percentage of copper (usually under 15%) vary greatly from the benchmark market price. For an analysis of mispricing, the distinction between exports of ore and exports of concentrate is highly relevant.

5.2. Drivers of abnormal undervalued exports of copper concentrate

For the year 2017, a more advanced approach uses the additional information found in the customs database. The analysis creates more precise estimates based on the LME free market price adapted to include the copper's concentration grade. It is assumed that concentrates originating within the same firm undergo a similar production process and thus, should have only slight deviations in quality in terms of concentration grade, byproducts and moisture. Following this logic, they should be valued at a similar unitary price despite the destination port.

The new estimates based on a free market price filter of 15% estimate the magnitude of undervalued transactions to reach US$ 3.8 billion in 2017. This equates to 32% of the year's total exports. The transactions were mainly destined to China (46.5%), Japan (15%) and India (0.7%). An in-depth analysis of the results identified Sociedad Minera Cerro Verde S.A.A, Mineria Chinalco Peru S.A and Hubday Peru as the three firms with the largest FOB values as magnitudes of under-invoiced transactions.

The identified transactions of Cerro Verde, whose parent company Freeport-McMoRan resides in the US, indicate no substantial differences in unitary transaction prices nor in the concentration grade across destinations. In the case of Chinalco, the subsidiary of Aluminum Corporation of China, the unitary prices and concentration grades differ slightly more, however the results are no conclusive indications, especially when considering that the exports to China show the highest unitary prices. The same is valid for Hubday Peru, the subsidiary of the Canadian Hubday Minerals. In the three cases, the 'mispriced' transactions represent between 57% to even 99% of their total exported values. These estimates are extremely high and need to be analyzed in detail. Consequently, the results observed in the 15% price filter can be explained by the following:

Despite adapting the market price to include the concentration grade, the quality of the concentrate is still influenced by other components that can have a higher impact in the transaction value than estimated by the selected price filter. Deductions for impurities or byproducts that do not reach the

established benchmark for payment, all have a negative impact in the expected price. Therefore, the price of Cerro Verde's copper concentrate might be easily explained by its quality.

Recurrent commercial practices can also further lower the final transaction price. For example, one interviewee pointed out that higher weight franchises might be applied when the destination ports are known to have inadequate infrastructure or incur in dubious practices to analyze the shipment's samples, ultimately causing unnecessary difficulties for the invoicing. The weight franchise is thus used to increase the attractiveness of the export. Additionally, quotation periods can result in deviation in final prices. These can be taken into account by comparing the transaction values to a 30 to 90 day moving average of the benchmark price depending on identified usual commercial practices.

As a result, the estimations from the 15% price filter should be interpreted with caution. Further, I found other differences within the identified transactions to be worth mentioning. For example, significant changes in transaction prices can be found in the exports of the mining firm Antapaccay S.A, a subsidiary of Glencore Plc, destined to China. The indicated copper grade of 39% is above the average, however this condition is not reflected in the average unitary price. This is a similar case for Glencore Peru S.A.C, whose exports to Mexico show a much lower concentration grade vis a vis other destinations. These findings need to be further investigated by looking at links between the exporting firm and potential assets in the country of destination, e.g. a refinery, that might motivate an underpricing of the export for profit shifting. Additionally, variations between the quality of the concentrate within the same exporting firm might be explained by the fact that some firms might have copper that comes from different mines. This observation must be taken into consideration in future analyses.

The sensitivity analysis gives the following results: For a 20% price filter, ab- normally under-valued transactions reach US$ 2.7 billion (23% of the total export value) with the main destinations being China (44%), Japan (21%) and the Republic of Korea (0.6%), closely followed by India (0.58%). As in the previous case, both Sociedad Minera Cerro Verde and Minera Chinalco lead the estimates, although the total share of mispriced values declined to 81% (from 99%) and 58% (from 86%) respectively. Again, there are no indications that the exports of Cerro Verde differentiate across destinations in terms of unitary prices or the grade of the exported concentrate questioning if the estimates are rather a result of e.g. the quality of the concentrate or of actual mispricing. This is a similar case for Chinalco. The third position is now occupied by IXM Trading Peru, whose identified transactions are destined to China and Namibia. The exports going to Namibia are particularly interesting, as they are valued considerably lower (a 34% difference) than the exports destined to China, despite the small difference in grade. Namibia is a destination known for hosting refineries which are able to process higher levels of arsenic in the copper concentrate. More arsenic however means higher deductions that affect the ultimate transaction price, which could explain the used price. Also interesting is the case of Minera Antamina, whose exports to China have a particularly high concentration grade while considerably deviating from the expected market price. The reason behind this difference needs to be further investigated.

For a negative 25% price filter, abnormally under-valued transactions equal US$0.7 billion (6% of the total export value) with the main destinations being China (44%), Japan (21%) and Namibia (14%). Again, the disaggregated estimates by firm change in terms of destinations and share of exports. Cerro

Verde's identified transactions considerably dropped to represent only 18% of their total exports with destinations ports being located in China, Japan and Spain. IXM Trading Peru also presents reduced estimates, although the identified exports to Namibia are still considerable. Other estimates, such as Glencore's exports to Mexico remained unchanged.

The analysis shows that the study of illicit financial flows, in particular related to the measure of the magnitude of trade mispricing, should not be restricted to identifying gaps in trade statistics, but further look into the motivations behind those gaps. Only an in-depth analysis of commercial practices in the country of study allows for a more precise estimation of price filters and thus of the extent of trade mispricing. Although I cannot entirely rule out its presence in the export of Peruvian copper concentrate, the in-depth study of the results indicates that trade asymmetries are rather driven by a combination of factors, starting from the differences in the quality of the concentrate from mine to mine. The research methodology must reflect this complexity. Taken at face value, the gaps identified in the three scenarios serve as indicative of under-invoicing by exporters of copper concentrate in Peru. Nevertheless, the in-depth analysis of the results in the three scenarios question the magnitude of the under-valued exports, and thus real existence of indicatives for illicit outflows by price manipulation.

5.3. Learnings from the analysis

Access to more disaggregated data, specifically with information on the concentration grade and the type of contents in the concentrate is key for a more precise analysis. The lack thereof might lead to inaccurate estimations of mispricing. Additionally, the customs database showed a lack of standardization in recording key information on copper exports. Spelling errors, incomplete data, variables changing from one exporting firm to another further challenged the analysis. A more precise disaggregation in the customs reporting method would be of much value. Overall, focusing on enhancing the transparency and accuracy of the reporting mechanisms can reduce the scope for export under-invoicing.

Another useful instrument is the DAM, which can be potentially used to match commercial practices and provide precise trade statistics that can facilitate regulation. The SUNAT has recently introduced an amendment to the DAM (box 7.35, paragraph 4 in section IV), requiring the customs forms to include specifics on copper grade, payable byproducts, penalizable elements, and moisture levels, all of which should be reflected in the columns of the tariff headings[21]. Additionally, a new resolution will require firms to provide detailed information on the exports (export characteristics and quotation period) on a separate form 15 days prior to the actual shipment date. Unfortunately, this resolution does not match the realities of the market where companies act in shorter time frames.

The additional information provided in the customs data allows to create sub- categories at the HS 8 or 10-digit level in the Peruvian customs classification, enabling to identify copper exports by grade/quality/value. This helps to further identify a relevant price filter and assess the risk of potential

[21] See the modifications in: http://www.sunat.gob.pe/legislacion/procedim/despacho/procAsociados/instructivos/ctrlCambios/it-00.04/cc-it.00.04-18-26-11-2017.htm

under-invoicing in the export of copper concentrate. Further research can include information on the payable byproducts to weight in their effect more precisely.

Several interviewees emphasized the need for a unit within the body of the Peruvian customs that has extensive expertise in the commodity trading business. Many felt that the evaluating entity did not show in-depth knowledge of recurrent commercial practices and of the variables that affect the price formation in the ex- porting sectors. Strengthening the expertise within the customs & tax authorities at the SUNAT can help to easier navigate through inconsistencies in the data.

Finally, there are further issues regarding the payment of concentrates worth revisiting. Concentrates are valued according to their contents, but byproducts are only paid when they meet an established threshold. In small quantities, these are not relevant, however as refineries and smelters get large amounts of concentrates, the magnitudes can change considerably. It might be valuable to review the total yearly amounts of gold, silver, zinc, etc. that are recovered from the tailings and do not have a declared price but ultimately create value for international buyers.

6. Conclusion

The mining industry is one of the key engines of Peru's growing economy. As the Latin American country aims to expand its project portfolio to capture 8% of the world's budget for mining exploration (Ministerio de Energía y Minas, 2017), the challenge remains on how to ensure the citizens can best benefit from this thriving industry.

With the bicentennial of Peru's independence in sight and as the country doubles down on its efforts to join the OECD, the country's need to strengthen its domestic resource mobilization and translate investments into fiscal spending that can fuel the country's development agenda becomes all the more urgent. Here, the fight against illicit financial flows - especially those originating from trade misinvoicing in commodity export - becomes pivotal. This paper seeks to uncover this issue.

This study conducted a price filter analysis to determine the existence and extent of abnormal pricing in the export of Peruvian copper concentrate from 2003 to 2017. In particular, the analysis looked for substantial deviations in the declared transaction prices by comparing them to the free market price for copper on the given date. The free market prices utilized are based on the LME daily price series and the trade statistics are based on the records of the Peruvian customs authorities of the SUNAT that includes all declared Peruvian exports of copper concentrate as recorded within the formal financial system. To provide a more nuanced picture, this paper was supported by qualitative data collected from interviews with key stakeholders of the Peruvian mining sector, which helped determine the price filters used to establish the acceptable range for price deviations.

Initial estimates underscore that empirical measurement techniques for estimating trade mispricing in commodity exports must account for the commodity characteristics, such as factors that affect commodity prices. Despite choosing a significantly high price filter of 90%, the analysis' validity remains restricted. Consequently, the analysis of export transactions in 2017 highlighted the added value of such an in-depth research approach. Depending on the selected price filters, the difference between the transaction prices and the free market prices is considerably reduced in comparison to the initial estimates. In many cases, the observed asymmetries can be explained by different hypotheses as informed by the qualitative interviews. Nevertheless, the gaps identified in all three scenarios indicate a level of export misinvoicing, which is worth further analysis.

This paper contributes to the literature of illicit financial flows in commodity trading on several aspects. First, the study emphasizes the need for country-level studies, and the backing of statistical analyses with an understanding of local commercial practices to avoid automatically attributing all statistical discrepancies to illicit flows. Aggregated analyses lack context specificity, and as a result, these might provide inaccurate estimates of the magnitude of illicit flows and of its channels.

Second, and in contrast to other existing studies that have utilized the price-filter methodology for the analysis of illicit flows, this study introduced an additional layer of detailed analysis based on the use of an extensive dataset from SUNAT. The quantitative analysis included a meticulous process of data cleaning and standardization, placing focus on the quality, purity and content of exports falling under the HS customs category to provide an additional layer of data reliability. This level of data disaggregation allowed the study to analyze the data at two levels, reviewing all transactions for the

entire study period and then running the analysis a second time for the year 2017 to include the additional information on the quality of the copper exports. For commodity concentrates, the empirical methodology for measuring trade gaps needs to consider the availability and complexity of the data, by including for example the variables that determine the used transaction prices.

An in-depth analysis requires more disaggregated, micro-level data that allows for robust estimates. In the case of concentrates, the current HS 6-digit HS classification is restricted by its broadness. It is worth discussing the benefits of creating subcategories in the HS 8-digit or 10-digit level to capture important differences that impinge upon the price of copper exports, such as grade, quality, and other values.

Future research needs to further analyze the identified under-valued transactions and dissect the information based on the exporting firm and destination port, and then cross-referencing it with information on firms' subsidiaries. Additionally, gaining access, even if somewhat restricted, to the annual declaration forms submitted by the exporting firms to the MINEM would allow to compare and complete information from customs data. Finally, a study of push-pull factors for IFFs-related activities, such as economic and regulatory drivers, would be invaluable in the Peruvian case.

Even though the presented estimates of abnormal pricing should not be interpreted as final evidence of trade mispricing in the export of Peruvian copper concentrate, the results are valuable indications of asymmetries that need to be further researched. Developing strong and reliable measurements can help the country identify current gaps and weak links to ensure that its citizens can ultimately reap the benefits of a thriving industry.

Appendix

A.1. Synthesis of main empirical IFFs methodologies

By their very nature, IFFs are difficult to detect and quantify, thus finding a suitable statistical method is especially difficult. Currently, no consensus over a correct methodology has been reached. Table 1.1 provides an overview of the diverse methodological approaches that have been used to quantify illicit flows.

Table 1.1.
Synthesis of the main empirical IFF methodologies

Method	Description	Shortcomings
Partner-country trade gap	Compares import and export statistics between trading partners for the same commodities	Aggregated trade data Reliability of trade statistics as bench- mark for arm's length prices Undifferentiated market practices Unable to detect abusive transfer pricing by MNCs
Price-Filter Analysis	Uses interquartile price range to determine if compared prices are within arm's length range	Endogeneity Effect of related party transactions Unclear counterfactual Identification of both under- and over- priced transaction Downward bias for large quantity transactions
Price-Filter Analysis with free market prices	Uses free market prices as a proxy to establish a legitimate price range It determines filters as upper and lower boundaries	Availability of free market prices for selected products Arbitrary selection of filters

The first, more predominantly used approach used to estimate trade misinvoicing is the partner-country trade gap method. Following the principle of double counting, this method uses mirror trade statistics to compare the import and export statistics between corresponding trading partners. Trade gaps, or estimated mismatches in data, are seen as proof of trade misinvoicing for both export under-reporting (positive gaps) or over-reporting (negative gaps) and can be calculated both at an aggregated level for all product categories as well as at the product level depending on the availability of data.

The studies based on this methodology have been widely criticized for the following limitations: i) aggregated trade gaps might cancel out misinvoicing effects of particular commodities ii) it is not possible to distinguish between legitimate and illegitimate transactions or if misinvoicing has been agreed by both trading parties; iii) it assumes that trade statistics of advanced economies are reliable and can be used as the arm's length comparative value whereas those of developing countries are not; and iv) only considers a 10% homogeneous margin between exports and import values to insurance and transport costs, not accounting for common commercial practices such as transit trade, for which the recorded export destinations deviate between partner country and ultimate buyer (Carbonnier and Zweynert de Cadena, 2015; Nitsch, 2016; Marur, 2019; Reuter, 2012). Existing studies that have used

the partner-trade gaps methodology have found substantial trade gaps largely estimating the size of illicit flows across countries and commodities[22]. Although these initial results are generalized assumptions instead of accurate detailed estimates, they are still used to evidence the importance of the phenomenon.

A second common method is the price-filter analysis, which uses the interquartile price range to determine if transfer prices are within arm's length range. The analysis compares prices between unrelated parties, determining the middle 50 percent of all observations as standard prized, and the highest and lowest 25 percent as abnormal. In this case, the accuracy of the results does not depend on the quality of the data of each individual trade partner as the analysis is applied to single country statistics (Carbonnier and Zweynert de Cadena, 2015). Furthermore, the level of data disaggregation allows to detect mispriced transactions without netting out effects.

This methodology has also been challenged, mostly due to issues concerning endogeneity and the identification of both under- and overpriced transactions even when these might be correctly priced.

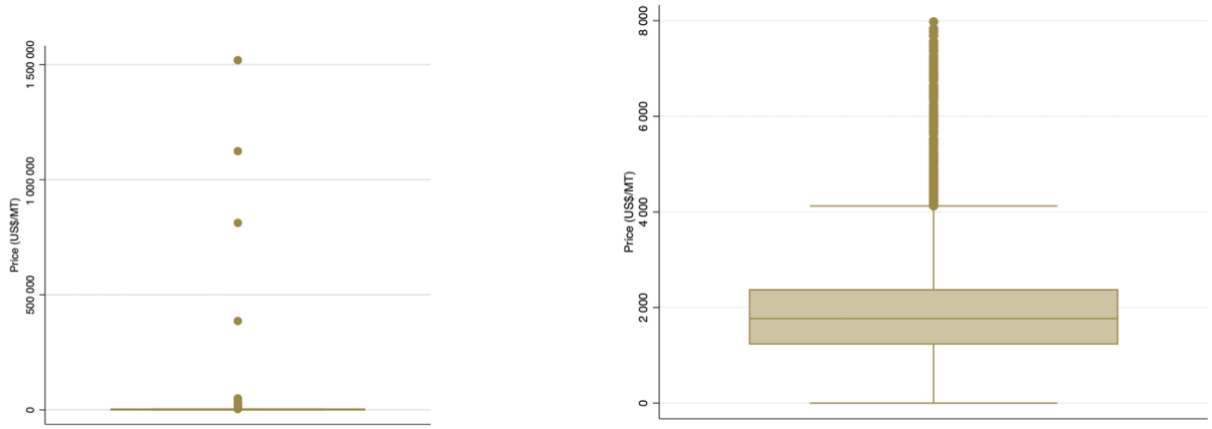
These critiques have been somewhat addressed by updating the methodology framework to include free market prices as a proxy for determining the acceptable range of legitimate price deviations (Carbonnier and Zweynert de Cadena, 2015). This framework builds the price filters as upper and lower boundaries around the free market price that represent the arm's length price range for the traded commodity in which transaction prices are normally priced. Only transaction prices that are located outside the determined range are assessed as abnormally priced. Despite the more micro-data approach, important limitations to this methodology include the availability of the market prices for the selected product and transactional data; the arbitrariness in the selection of the price filters; the focus on unit prices instead of quantities, and the difference between the transaction sales date and the customs record date, which might result in a difference in the used free market price.

A.2. Summary Statistics

Figure A.1 shows the distribution of the calculated unitary prices for all observations. The prices indicate a mean unitary price of US$ 2428.12 with strong outliers. 90% of all observations indicate a price below US$ 3351.07. Due to the strong deviation to the distribution and mean values, I exclude 125 transactions that have a unitary price above US$ 8000 and represent only 1.16% of the total. The new mean unitary price lies at US$ 1941.74.

Figure A.1 Distribution of unitary transaction prices in US$/MT, 2013-2017

[22] See for example the estimates of the Global Financial Integrity reports from 2008 – 2017, whose estimations range from US$ 850 billion to US$1.3 trillion per annum for developing countries. Baker's first report estimated that around US$ 1 trillion of dirty money moves across borders annually, from which US$ 500 billion are streamed mostly unrecorded out of developing and transitional economies. Global Financial Integrity (GFI) reports (Kar and Freitas, 2012; Kar and Spanjers, 2014; Salomon and Spanjers, 2017) are published almost on a year basis as global or country-specific estimates.



(a) initial (b) adapted

The statistics are presented for the key used variables:

Table A.1.
Summary statistics

Copper concentrate					
	N	Mean	Std. Dev.	Max	Min
Quantity (in mt)	10,618	4974.51	5650.52	0.002	33860.04
Fob Value (in US$)	10,618	7783471	9321943	0	7.38e+07
Unit Price (in US$)	10,618	1941.9	1024.42	0	7977.44
LME Copper Grade A - Daily Price Series					
	N	Mean	Std. Dev.	Max	Min
LME Spot	7,371	6429.545	1525.541	1579.5	10070
LME Spot extended	10,620	6469.593	1552.405	1579.5	10070
Additional Information					
	N	Mean	Std. Dev.	Max	Min
CU Grade	1,084	25.58%	0.0690236	62.7%	4.53%
Graded LME Spot	1,084	1596.26	453.44	5681.81	289.2065

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