CODERA ANALYTICS

Assessing Potential Trade Misinvoicing and Data Quality Issues in South African Exports

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Abstract

Trade misinvoicing — the deliberate falsification of volumes, values or classifications of traded goods by at least one party in an international transaction — can undermine the accuracy of trade data, erode a country's tax base, or facilitate illicit financial flows. South Africa has been flagged as one of the world's largest sources of illicit financial flows from illicit trade, cross-border laundering and mineral smuggling. Data availability however makes it difficult to assess this empirically. We compare South Africa's reported export and global counterpart import data to quantify the potential scale of export misinvoicing in South Africa. We show that the data suggest that there has been systematic under-invoicing of South African commodity exports. However, we also highlight data limitations that constrain accurate assessment of trade misinvoicing. The scale of possible misinvoicing is significant. If taken literally, our findings suggests substantial foregone mineral royalties for the South African fiscus. Our back-of-the-envelope estimates range between R30 to R50 billion for the period 2015-2024. Our estimates of foregone fiscal revenue suggest that investing in capacity to monitor trade misinvoicing would therefore be self-funding.

JEL classification: F13, F14, F38, H26

Keywords: trade misinvoicing, tariffs, tax evasion

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1 Introduction[1]

Illicit economic activity imposes a substantial fiscal burden on South Africa, with the South African Revenue Services estimating that between 5%-8% of GDP is lost to illicit activities South African Revenue Service (2026), creating billions of rands in forgone tax revenue. While not all illicit activity involves cross-border trade, trade misinvoicing is one mechanism used to facilitate illicit financial flows. Trade misinvoicing is the deliberate falsification of volume, value and/or the type of commodity recorded by at least one party in an international transaction. Over-invoicing imports, for example, is one avenue to launder illicit income across borders. Under-invoicing by domestic exporters bypasses exchange controls, reduces their taxable corporate income or shifts profits to other tax jurisdictions. Export over-invoicing, on the other hand, is a way to fraudulently claim export subsidies or value-added tax (VAT) rebates, or repatriate illicit offshore funds.

Trade misinvoicing appears to be a significant problem in South Africa. A study by Global Financial Integrity (2026) notes that between 2013 and 2022, there was a gap of almost US$500 billion in the value of traded goods reported by South African goods exporters and our trading partners. If these estimates are correct, this would represent a significant loss in potential tax revenue. The study also suggests that deliberate manipulation of export invoices for primary commodities has historically served as a conduit for capital flight in South Africa.

Along with renewed interest being directed to understanding the illicit economy and cross-border trade, the continued institutional challenges faced by South Africa, including insufficient support to monitoring and enforcement agencies and the collapse of container port infrastructure, makes an assessment of trade misinvoicing especially pertinent.

A key challenge for studying misinvoicing is the availability of domestic and counterpart trade data. Our study relies on publicly available data, for which only export data have comprehensive counterpart information. This limits the scope of our analysis to export misinvoicing in South Africa, for the period covering 2015 to 2024. Furthermore, our study's focus is restricted to illicit outflows via export under-invoicing in mineral resources. We focus on the mining and mineral resources sector for several reasons. Firstly, mineral products, precious and base metals represent around 50% of South African exports. Secondly, the prevalence of multinational corporations with strong political and commercial ties to other entities may create an increased risk of transactions that violate the arm's length principle not only via transfer mispricing, but also through trade misinvoicing.[2] Thirdly, mineral smuggling has become of increased concern for enforcement agencies over recent years. National legislation that bears on mineral resources also imposes royalties based on gross sales (as well as export levies on chrome ore or scrap metal), which may incentivise under-reporting of sales. Lastly, several previous studies into misinvoicing in developed countries have focused on the mining and minerals sector, allowing us to compare our findings with others.

The paper proceeds with a discussion of the data used and methodology employed, followed by an investigation of the results. The results section includes analyses of a selection of commodities for which sufficient data are available. To validate our results, we also compare Comtrade data to South African Revenue Services (SARS) trade data (made available by Stratalyze and available via EconData (Codera Analytics, 2025).[3] We also calculate of how much tax revenue may have been lost to misinvoicing. Lastly, we assess whether commodity misinvoicing

[1]We thank Riaan Grobler for comments and suggestions.

[2]While transfer mispricing constitutes another means of illicit outflows, the estimation of mispricing is beyond the scope of this paper.

[3]EconData makes it easy to access aggregated SARS trade data for South Africa.

is unique to South Africa, or whether trade reporting imbalances are also observed for other countries.

We show that the data suggest that there has been systematic under-invoicing of South African commodity exports. However, we highlight data limitations that constrain accurate assessment of trade misinvoicing of South African as well as other countries' exports and imports. We argue that improvements in data collection and monitoring is important to combat potential illicit financial flows.

2 Methodology and Data

As we are interested in financial flows, value measures are preferred to volume measures for misinvoicing analysis. Volume imbalances may still be indicative of illicit activity as understating or over-stating quantities may indeed be a means of diverting trade through poorly monitored channels. However, monetary values are preferred as these are more explicitly linked to financial flows. Our approach to investigating illicit outflows is via imbalances in the monetary values reported by South African exporters and foreign importers using the following equation:

$$DX^k_{i,t} = M^k_{i,t} - \beta X^k_{i,t} \tag{1}$$

where the magnitude of $M^k_{i,t}$ is the imports of commodity k recorded by partner country i from South Africa and $X^k_{i,t}$ is the value of exports to country i as reported by South Africa and β is the freight and insurance factor. In equation 1, a positive value of $DX^k_{i,t}$ would be indicative of export under-invoicing, while a negative value suggests export over-invoicing. For the purpose of this study, the sample period is restricted to the decade spanning between 2015 and 2024, as 2025 data was not fully available at the time of writing. To make values comparable across years, we calculate the ratio of the difference over the FOB values for that year.

There are various data challenges that must be confronted for this type of analysis. The first issue that we account for in our approach is that bilateral imbalances may arise from situations when the reported export destination differs from the country where the corresponding import is recorded owing to, for example, re-exporting. This is especially relevant for exports to European countries, with the presence of what is known as the 'Rotterdam Effect', which is associated with traded goods being attributed to trans-shipment countries as opposed to their actual final destination (see Ostensson (2018) for more). We account for this by basing our primary analysis on South Africa's aggregated reported flows with the rest of the world as a combined unit for each of the commodities. Another issue to note is that the same commodity category may be classified under different sub-heading categories between two countries. To address this, we aggregate sub-headings into appropriate category headings. Finally, and perhaps the biggest obstacle to conclusive analysis of trade misinvoicing, is general data incompleteness. South Africa, for example, does not report detailed information on exports of gold, with estimates of values by destination depending on what is reported by partners. As a result, we restrict country-level commodity analysis to groups for which 75% of trade value (by FOB value) has both CIF and FOB values available, namely chrome, coal, copper, iron, manganese and platinum[4]. Together, these commodities comprise nearly 30% of the dollar

[4]While cobalt exports pass this threshold, the European Union (which made up over 75% of exports of this category) reported imports are very small relative to South Africa's reported exports to the European Union. We

value of South African exports over our 10-year sample.

While this approach identifies imbalances in a direct manner, it remains difficult to identify potential source of misinvoicing. In cases where the reported export free-on-board (FOB) value exceeds the corresponding reported import value after taking into account the cost of insurance and freight, for example, it may be that either the importer has under-invoiced or that the exporter has over-invoiced.[5] As mentioned previously, there may be many reasons for trade misinvoicing, including fVAT rebates offered on exports that may induce exporters to overstate their invoices. Insofar as rebates would incentivise over-invoicing of exports, however, this would only reduce the sensitivity of our results. If, despite the presence of rebates, we find totals of FOB values to exceed CIF values, it is all the more likely that there was under-invoicing taking place for a given commodity in a specific year.

The United Nations' Comtrade database provides detailed information on international trade, with monthly Dollar values and volumes reported by member countries across more than six thousand commodity classifications. Comtrade generally provides information reported by exporters (FOB values) as well as importers (CIF values) on a monthly basis. The availability of CIF and FOB values makes it possible to use the aforementioned mirroring approach to detect possible misinvoicing. Despite steps being taken to avoid obvious reporting errors by Comtrade, there remain some issues with the data. As we show in the sections that follow, the data is characterised by inconsistent reporting as members do not always report exhaustive or even sufficiently comprehensive information. For example, South Africa does not provide CIF values of its imports at the six-digit (subheading) level, preventing the estimation of misinvoicing through imports. More problematic for our analysis is an absence of sub-heading-level import information from China in 2015 and 2017. To resolve this issue, we gathered the 4-digit (heading) level data directly, instead of summing together sub-heading-level figures as was done for other partners. This issue was not encountered for any other major trading partner.[6] Another limitation of the data used is that only the totals of groups of individual transactions are available, prohibiting analysis of potential transaction-level misinvoicing.

To provide a broad overview of the data we use, the figure below plots the distribution of our misinvoicing measure across all HS headings. It is clear that the data contains many extreme values (which may reflect data issues rather than deliberate misinvoicing) and that there are variations in the distribution of these metrics across the sample period. As a result, we also consider alternative results where we control for potential reporting issues by discarding observations with misinvoicing values greater than the full FOB values. Following equation 1, this restriction implies excluding all observations where one of the components of the equation equal zero. The impact of this restriction is to shift the mean and median values of the distribution to the left since a large part of the positive tail of the distribution is restricted. The negative mean and medians across the restricted sample reflects either that South African exporters tend to invoice lower values than South Africa's counterparties, or that export under-invoicing often takes on magnitudes less than negative 100%. The downside of restricting the sample in this way is that it constrains our ability to undertake country-level analysis if large country-level imbalances reflect the impact of misallocation of origin or destination owing to re-exporting. In the sections that follow, we present both baseline and restricted sample results.

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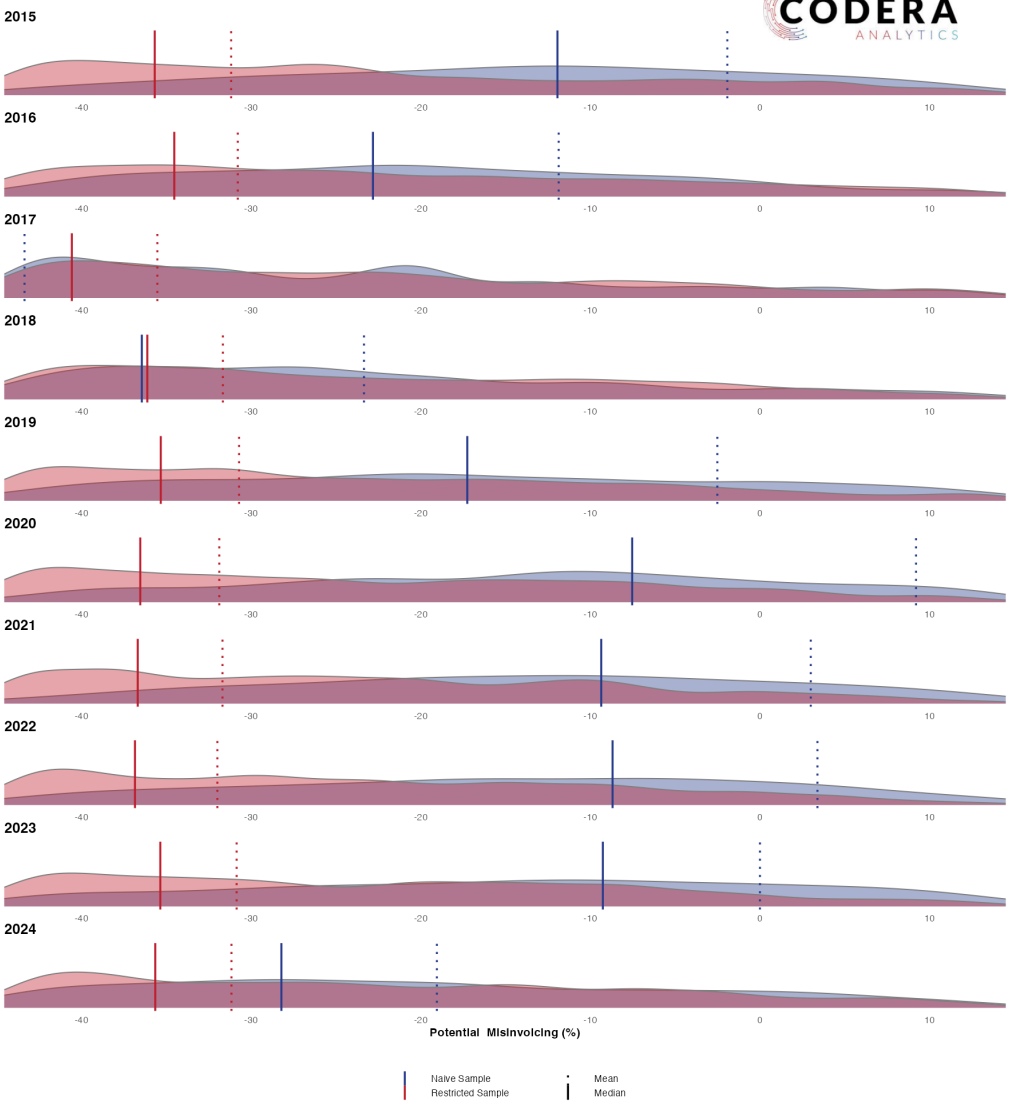
therefore excluded the category from our analysis.

[5] Note that we adjust FOB values by 8% to account for shipping and insurance costs.

[6] While we sum together sub-heading values to obtain our estimates, we also checked whether estimates differ when using 4-digit classification. Results were not affected.

Distribution of Export Misinvoicing, 2015-2024



Source: UN Comtrade
Notes: Commodities are aggreagted to HS4 levels and then grouped.

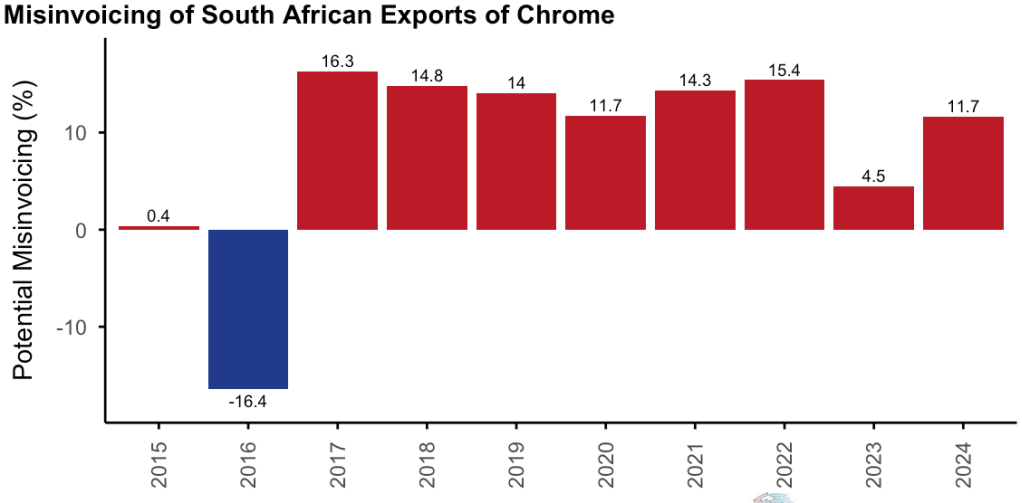
To assess the implications of potential export under-invoicing, we also calculate the the potential fiscal revenue losses over our sample when FOB values exceed CIF for a commodity category, under a maximum unbeneficiated mineral royalty of 7%. As South Africa does not have export subsidies for raw minerals, we ignore the possibility that over-invoicing could imply fiscal costs, although VAT rebates for exports may result in misreporting.

3 Misinvoicing Estimates

3.1 Chrome

South Africa holds nearly two thirds of global chromium deposits and is the largest exporter in the world. Chromium ore accounted for 2.5% of the dollar value of total South African exports over the decade between 2015 and 2024. If the sample used is unrestricted, 2016 stands out as the only year in which potential over-invoicing is identified, with FOB values exceeding CIF values by 16% of the total FOB value. The year 2015 shows no evidence of misinvoicing, while export-import data imbalances range between 4% to 16% of total trade value for 2017 to 2024.

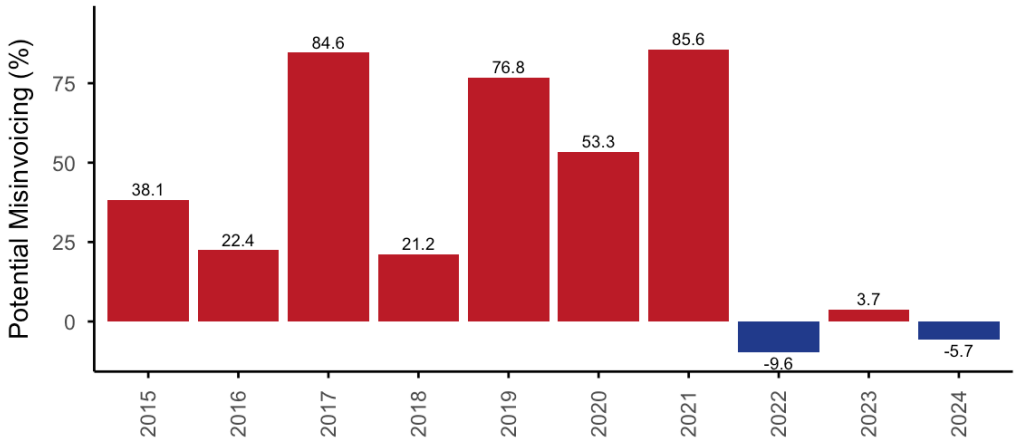
Country-level data in Table 5 in the Appendix show that China's reported CIF values are nearly twice as large as South Africa's reported FOB values. However, as we show later for other commodities, re-exporting may obscure true trade flows. For South Africa, re-exports via Mozambique creates challenges for country-level analysis, with large FOB values and small CIF values reported reflecting asymmetric reporting. An earlier study of Zambian copper exports by Mudenda and Ndikumana (2024) overcomes this issue through the use of triangular trade analysis of large imbalances. However, such an undertaking is beyond the scope of this study, in which our primary focus is on aggregated balances. A possible explanation, however, is that Mozambique and Hong Kong's small CIF values relative to their FOB values are a result of importers in these countries not reporting imports from South Africa, as they are simply re-exported to other countries like China, while South African exporters designate the re-export locations as their final destinations. Indeed, re-assigning the bulk of FOB reports from these two countries to China could partially offset the positive misinvoicing estimate for China and the negative values of Mozambique and Hong Kong. Nevertheless, a substantial amount of potential under-invoicing would still be measured for exports to China.



Source: UN Comtrade
Note: values are expressed as the excess import value reported as a percentage of free-on-board values multiplied by a freight factor of 8%.

If we instead restrict the sample to address the data issues described earlier, we find several years of substantial potential under-invoicing, particularly in 2017, 2019 and 2021. A possible explanation for the observed pattern in the figure below is that the unrestricted estimates are lowered by the removal of large negative values for Mozambique and Hong Kong, both of which reported much lower import values from South Africa than was reported by South Africa over the sample period. This demonstrates the conceptual challenge with the restricted approach, as positive and negative values resulting from re-export origin/destination misallocation would otherwise net out, are dropped from our sample. This means that we measure a more limited portion of South African chrome exports under this approach. The differences between the approaches demonstrate the sensitivity of trade misinvoicing evaluations to data cleaning choices. However, the data suggest that under-invoicing is more likely than over-invoicing over our sample.

Misinvoicing of South African Exports of Chrome (Restricted Sample)



Source: UN Comtrade
Note: Values are expressed as the excess import value reported as a percentage of free-on-board values multiplied by a freight factor of 8%.
Values exceeding 100% over or under were dropped.

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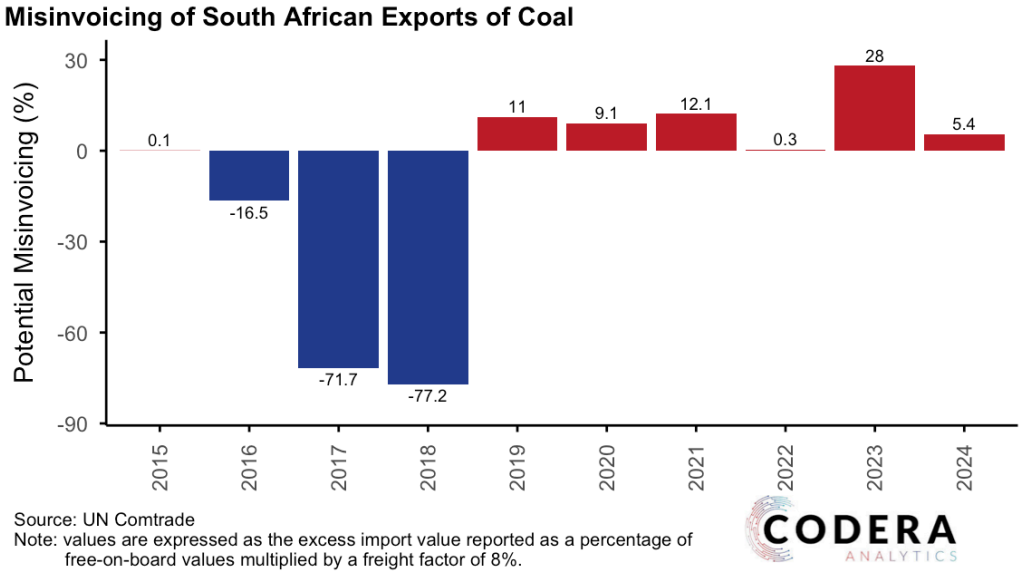
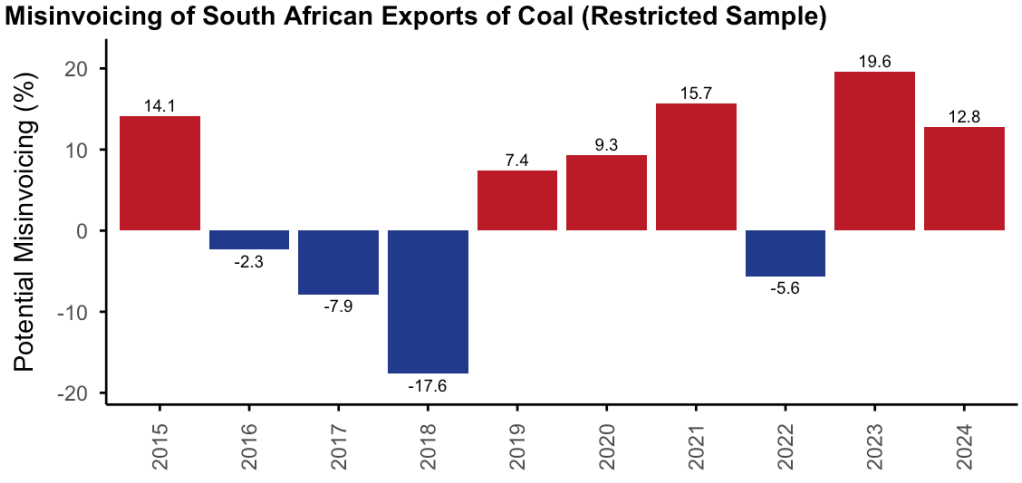
3.2 Coal

South Africa is a large global coal exporter. In an unrestricted sample, the differences between the CIF values reported and the FOB after adjustment for CIF factors, is negative between 2016 and 2018 and positive thereafter, suggesting potential export under-invoicing over the latter part of our sample. At a country-level, misinvoicing is generally negative (Table 6 Appendix). By our assumptions, these substantial values indicate misinvoicing by importers who under-invoice relative to the true value. For Mozambique, the value is highly negative at -102%. This may be explained by re-exporting being reported differently between exporters and importers. South African exporters report coal as being bound for Mozambique when in reality it is simply being shipped via Mozambique and thus there is no corresponding record by Mozambique.



Source: UN Comtrade
Note: values are expressed as the excess import value reported as a percentage of free-on-board values multiplied by a freight factor of 8%.

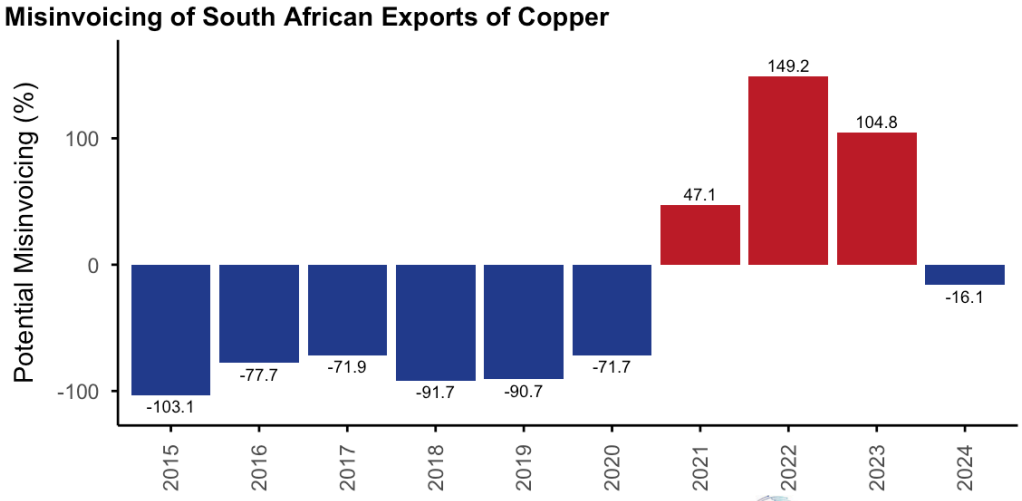
Moving to a restricted sample, the pattern of potential misinvoicing tends towards more moderate values — 2016, 2017 and 2018 are no longer as highly negative, implying the large estimates in the previous chart were likely driven by outliers. The removal of excessively large misinvoicing observations of coal exports also sees the overall misinvoicing level in 2015 increase substantially, with potential under-invoicing of around 14% of total coal exports.



Source: UN Comtrade
Note: Values are expressed as the excess import value reported as a percentage of free-on-board values multiplied by a freight factor of 8%.
Values exceeding 100% over or under were dropped.

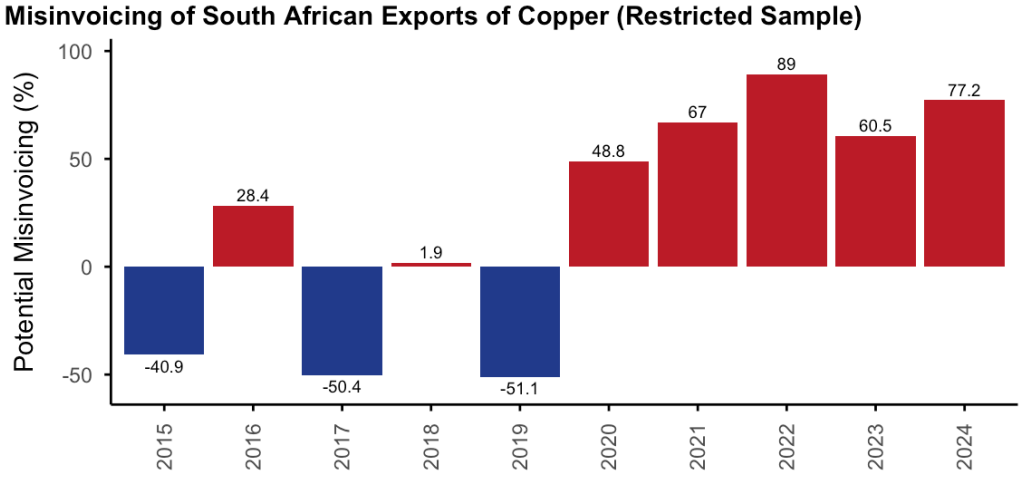
3.3 Copper

In an unrestricted sample, we find negative imbalances for copper ore exports, with very large negative potential misinvoicing values recorded in all years prior to 2021. Thereafter, values turn strongly positive between 2021 and 2023. In Table 7 in the Appendix, we see that while misinvoicing to Mozambique was highly negative, China's estimates are positive. This may again be a result of incorrectly assigning copper exports as bound for Mozambique when they are bound for China. In fact, subtracting Mozambique's CIF from its FOB and allocating that amount to China would balance out both of their data imbalances. Nevertheless, substantial imbalances persist across other partners and across time.



Source: UN Comtrade
Note: values are expressed as the excess import value reported as a percentage of free-on-board values multiplied by a freight factor of 8%.

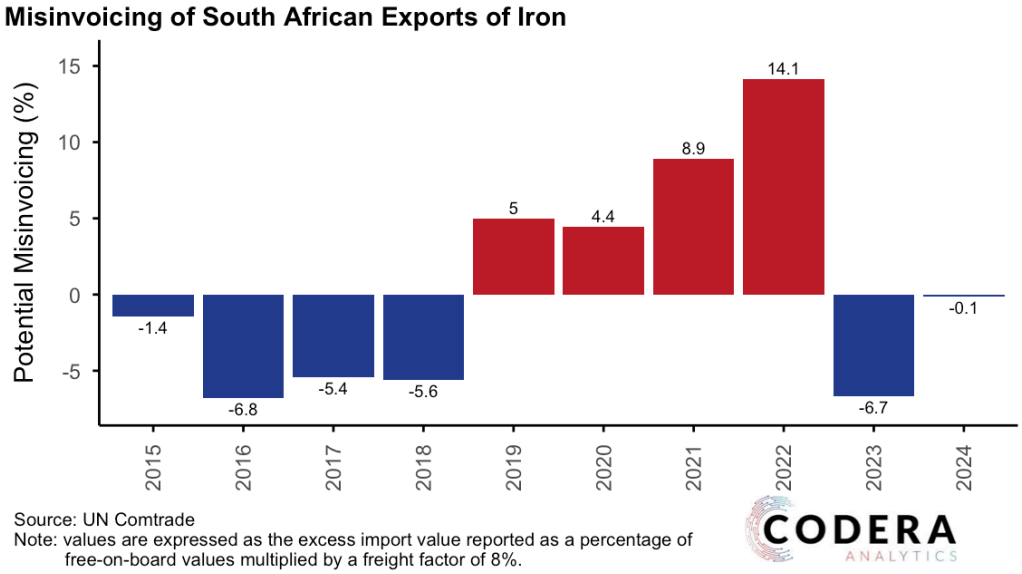
Restricted sample estimates also suggest large imbalances for copper exports. After omitting large imbalances, we find potential instances of under-invoicing ranging between 48% of and 89% of reported exports between 2020 and 2024, while 2016 also showed a substantial level of potential under-invoicing. As would be expected, the inter-year range also narrows under a restricted sample, ranging between -51% and 89% instead of -103% to 149%.



Source: UN Comtrade
Note: Values are expressed as the excess import value reported as a percentage of free-on-board values multiplied by a freight factor of 8%.
Values exceeding 100% over or under were dropped.

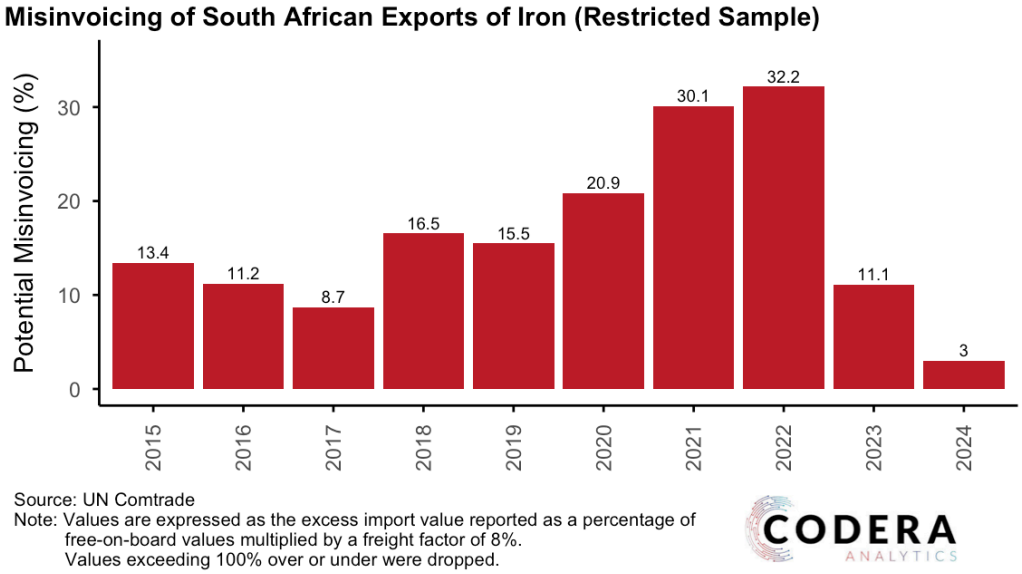
3.4 Iron

Our unrestricted sample, we identify potential export under-invoicing in four of the ten years in the case of iron exports. The year with the highest level of potential under-invoicing is 2022, at around 14%. Unlike copper exports, it is unlikely that this can be fully explained by re-exporting via neighbouring countries, since most of South Africa's iron ore is exported via the Sishen-Saldanha corridor. However, a country-level breakdown shows that a sizeable amount of exports are still bound for Mozambique possibly before being re-exported to other markets (Transnet Port Terminals, 2013). Throughout our sample, potential misinvoicing levels are relatively moderate, although 2021 and 2022 saw exports being under-reported by 9% and 14%, respectively. Consistent with these estimates, Ndikumana (2016) find that South African iron exports were under-invoiced prior to 2015.



Source: UN Comtrade
Note: values are expressed as the excess import value reported as a percentage of free-on-board values multiplied by a freight factor of 8%.

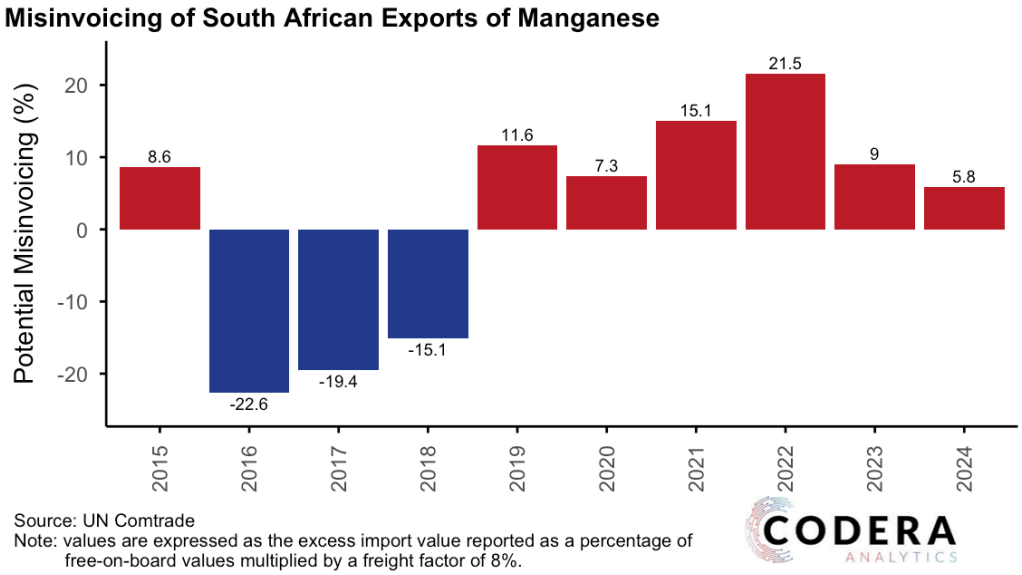
When we restrict the sample, iron exports display strong evidence of potential under-invoicing for all of the years in the sample.



Source: UN Comtrade
Note: Values are expressed as the excess import value reported as a percentage of free-on-board values multiplied by a freight factor of 8%.
Values exceeding 100% over or under were dropped.

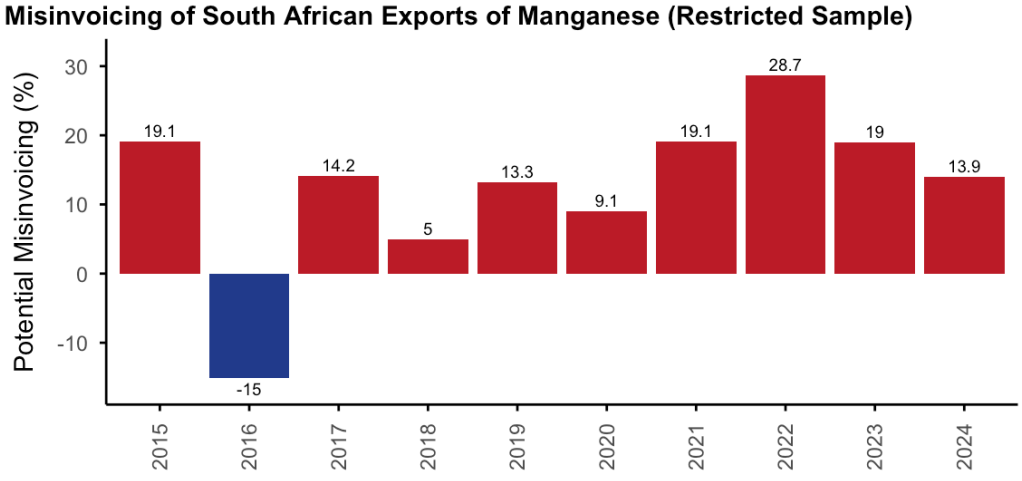
3.5 Manganese

South Africa is the world's largest exporter of manganese ore, accounting for nearly 50% of global exports in 2024 (Observatory of Economic Complexity, 2024). Between 2016 and 2022, manganese misinvoicing patterns share a resemblance with potential iron misinvoicing, with negative values reported for the early part of the sample, before positive values are observed between 2019 and 2024. While both iron ore and manganese ore mining is concentrated in the Northern Cape, perhaps a more noteworthy commonality between the two is their importance for Chinese steel production.



Source: UN Comtrade
Note: values are expressed as the excess import value reported as a percentage of free-on-board values multiplied by a freight factor of 8%.

For a restricted sample, we find consistent evidence of potential export under-invoicing of manganese exports. While not changing as drastically as iron, potential misinvoicing is now more positive across all years, with only 2016 not reporting positive potential misinvoicing value. This again reflects the removal of extreme negative values that may have swamped out under-invoicing estimates.

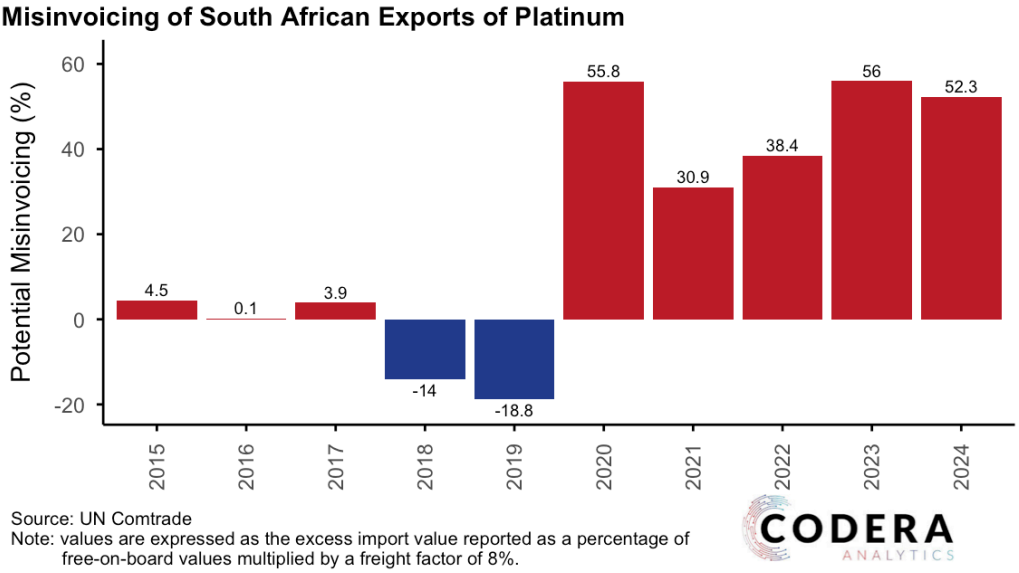


Source: UN Comtrade
Note: Values are expressed as the excess import value reported as a percentage of free-on-board values multiplied by a freight factor of 8%.
Values exceeding 100% over or under were dropped.

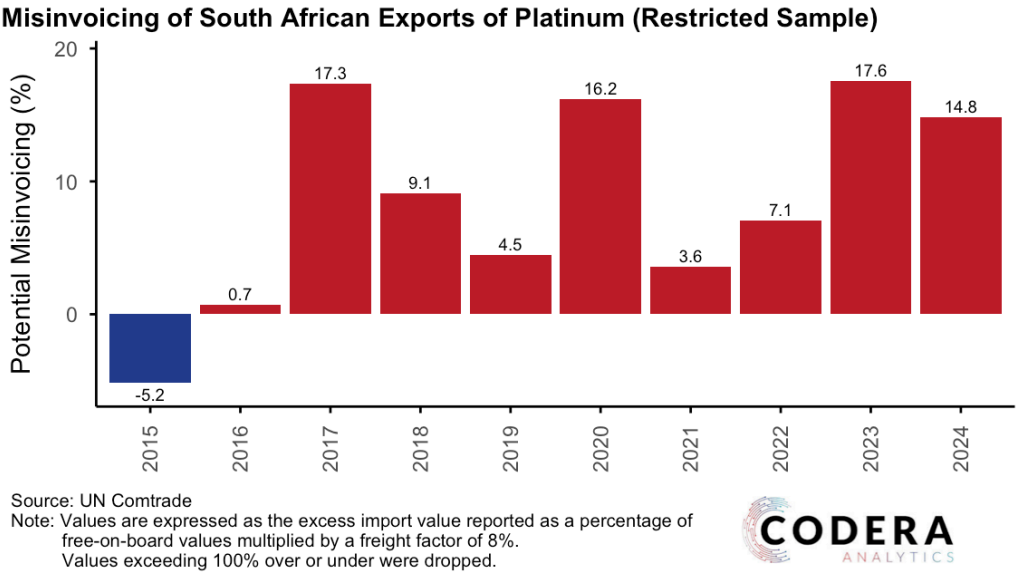
3.6 Platinum

Apart from gold, platinum was the largest contributor to South African exports over our sample, making up around 12% of total FOB export values. Our estimation shows a strong uptick in potential platinum export under-invoicing from 2020, with prior years seeing very low levels of potential misinvoicing, with 2018 and 2019 showing under-invoicing. In the 5 most recent years, degree of potential under-invoicing is substantial. In 2020, 2023 and 2024, the difference between CIF values and CIF-factored FOB values was over 50% the size of exports reported by South African exporters.

These values may have been inflated by very low FOB values reported with China: while South African platinum exporters reported around US$2.4 billion of exports over the sample period, Chinese importers reported nearly US$25 billion in imports from South Africa. As seen in Table 12 in the Appendix, it is the result of consistently high differences in values reported between South Africa and China across all years in the sample, which may result from reporting issues by either of the two partners.



Having removed the large imbalances with China from all ten years, we still find strong evidence of potential under-invoicing in our data. In a restricted sample, we find in nine of the of the ten years in our data displayed potential under-invoicing, with 2018 and 2019 both becoming positive even after the removal of China's large positive contribution. The restricted sample provides even more plausible evidence of under-invoicing in that its range of values is smaller and less extreme as it is purged of extreme outliers. Although we find a switch from under-to over-invoicing across the two halves of our unrestricted sample, the restricted sample indicates potential under-invoicing to be a more persistent feature in platinum exports, as was found in Ndikumana (2016), although their estimates included platinum along with silver.



4 Overall scale of misinvoicing

The previous section provided a visual summary of possible misinvoicing patterns across time and across commodity exports. Tables 1 and 2 summarise the differences between the total FOB and CIF values reported over the sample period for each commodity. Both tables indicate very large excess values, reflecting CIF values being much higher than FOB values, even after applying an 8% CIF factor to the FOB values. In our unrestricted sample, coal and copper exports have very large negative imbalances (indicating exporter over-invoicing), while chrome, iron and manganese recorded net positive values equal to R35 billion, R17 billion and R15 billion respectively. For platinum, the value is exceptionally high at R485 billion. However, this is likely to be driven by the large disparities reported with China, as previously discussed. The difference between the CIF values and the FOB reported for the six commodity categories considered suggests about R414 billion and R490 billion rand.[7] This represents about 19.5% of total FOB exports without a CIF factor, and 11.5% when including it.[8]

Table 1: Unrestricted Sample Estimated Difference (R Million), 2015-2024

Commodity	FOB Value	CIF Value	Excess
Chrome	363 863	427 929	34 957
Coal	925 055	941 519	-57 540
Copper	33 584	30 777	-5 493
Iron	893 620	982 480	17 370
Manganese	394 903	441 829	15 333
Platinum	1 654 229	2 271 712	485 145
Total	4 265 254	5 096 246	489 772

Note: Excess equals CIF values less FOB values multiplied by 8%.
Dollar values are converted to rands by multiplying by average annual exchange rates.

The restricted sample also demonstrates very large differences between FOB and CIF totals.

[7] Estimates from the Ndikumana (2016), by comparison, suggest under-invoicing amounted to R70 billion (in 2014 prices) between 2000 and 2014 for silver, platinum and iron ore and gold.

[8] A large part of the within-commodity difference are hidden once we add all of the non-platinum commodities, with an 8% difference before applying a CIF factor, with coal and copper reversing the positive differences seen across the other three minerals.

In fact, all commodities apart from platinum are now larger, with coal and copper shifting to under-invoicing. As noted earlier, the restricted sample excludes extreme negative as well as extreme positive observations. Overall, the difference between the FOB and CIF values amounts to 20.5% of the value reported FOB value in our sample. Adding an 8% CIF factor still leaves a 12.5% difference between the values reported by South African exporters and those reported by their counterparties.

Table 2: Restricted Sample Estimated Difference (R Million), 2015-2024

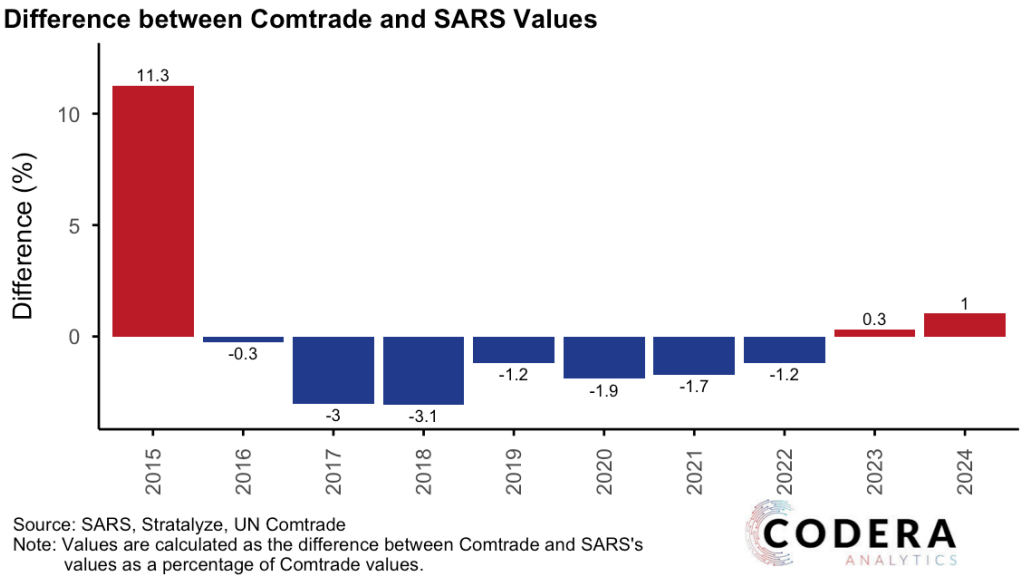
Commodity	FOB Value	CIF Value	Excess
Chrome	103 197	169 960	58 507
Coal	721 065	826 780	48 030
Copper	14 244	24 155	8 771
Iron	687 716	858 962	116 228
Manganese	354 844	433 043	49 811
Platinum	1 426 296	1 673 371	132 971
Total	3 307 362	3 986 269	414 318

Note: Excess equals CIF values less FOB values multiplied by 8%.
Dollar values are converted to rands by multiplying by average annual exchange rates.

Across both the unrestricted and restricted samples, we find very large differences between CIF and FOB values. Two potential explanations could be that differences in the periods in which invoices are recorded could create discrepancies. For example, if a product is recorded as delivered in January 2015 despite being exported from South Africa in December 2014, we might find 2015 to have more CIF records than FOB records. However, this is unlikely to have a material impact on our results as CIF imbalances from the beginning of the year are likely to be counterbalanced by unmatched FOB values at year-end.

A second explanation could be that exchange rate conversions may impact results. We assesses this by comparing Comtrade data to official SARS trade data provided by Stratalyze. Unfortunately, we cannot consider balance of payments data (published by the Reserve Bank) as this does not provide commodity breakdowns. SARS reports data in rands, while Comtrade converts reported data to dollars. We convert SARS trade values to dollars using monthly exchange rate averages for comparison. The differences between the two sources provides an indication of whether or not exchange fluctuations may have affected recorded values. If conversions from rands to dollars using monthly averages is found to generate large differences with Comtrade's conversion methodology, we cannot rule out the possibility that exchange rate fluctuations might contribute to the misinvoicing detected in our data.

In the figure below, differences between the datasets are small, with the exception of 2015, where values reported in Comtrade are on average 11.3% higher than corresponding values from SARS's data for the commodities in our sample. Rather than being driven by a single outlier, we see in Table 13 in the Appendix that the differences are range between 10% and 12% across the six commodities for that year. One explanation could be that Comtrade consistently used a weaker value of rand at the time of compiling the statistics. For the other nine years, the difference between the sources ranges between -3% and 2% — a relatively narrow band. Although both SARS and Comtrade report data at a monthly frequency, this suggests that differences in conversion approaches do not create systematic differences to export values in our dataset.



5 Revenue Losses

Illicit financial flows via trade misinvoicing represent problems for the state's fiscal positions as taxable revenue is funneled out of the country. We calculate estimates of foregone tax revenue using both our unrestricted and restricted samples. In light of the shortcomings noted earlier, both of these samples require us to consider these estimates with caution. On one hand, our estimates from the unrestricted sample may be distorted by large outliers, such as those seen in platinum misinvoincing. On the other hand, our restricted sample calculations are based only on exports to partners within the exclusion thresholds, implying that the values do not reflect the totality of mineral exports. For the sake of simplicity, apply a 7% mineral beneficiation tax on potential under-invoiced values to estimate uncollected tax liabilities to the state.

Table 3: Unrestricted Sample Estimated Revenue Foregone (ZAR Million), 2015–2024

Year	Chrome	Coal	Copper	Iron	Manganese	Platinum
2015	4	4	—	—	87	270
2016	—	—	—	—	—	9
2017	302	—	—	—	—	237
2018	253	—	—	—	—	—
2019	268	506	—	292	368	—
2020	209	368	—	309	210	6 922
2021	271	723	126	898	432	7371
2022	433	38	315	1 053	711	7 318
2023	227	2 653	308	—	308	7 746
2024	698	394	—	—	231	6 659
Total	2 664	4 684	748	2 552	2 347	36 532

Note: Misinvoicing estimates multiplied by annual average USD/ZAR spot rate to obtain ZAR values. A maximum 7% (unbeneficiated) mineral royalties rate was applied.

Taking our misinvoicing calculations literally for the categories of exports considered, the maximum revenue losses associated with commodity export under-invoicing for the period 2015-2024 would total around R50 billion in our unrestricted sample and closer to R30 billion in the

Table 4: Restricted Sample Estimated Revenue Foregone (ZAR Million), 2015–2024

Year	Chrome	Coal	Copper	Iron	Manganese	Platinum
2015	314	401	—	432	176	—
2016	207	—	11	348	—	31
2017	986	—	—	314	241	685
2018	34	—	0	536	134	352
2019	934	367	—	705	411	180
2020	686	366	37	1 137	240	1 932
2021	958	843	143	2 107	498	8439
2022	—	—	186	1 689	880	1 324
2023	6	1 673	156	669	594	2 368
2024	—	797	106	199	513	1 821
Total	4 123	4 446	639	8 1367	3 686	9 535

Note: Misinvoicing estimates multiplied by annual average USD/ZAR spot rate to obtain ZAR values. A maximum 7% (unbeneficiated) mineral royalties rate was applied.

restricted sample. It is worth emphasising again that this figure excludes gold exports, where there may likely be higher levels of under-invoicing, but where accurate analysis is constrained by data availability. Another limitation of our figures for revenue losses is that our calculations can only estimate revenue losses where there was net under-invoicing, meaning that it is not possible to estimate how much revenue was lost in instances where transaction-level under-invoicing was 'hidden' by aggregation.

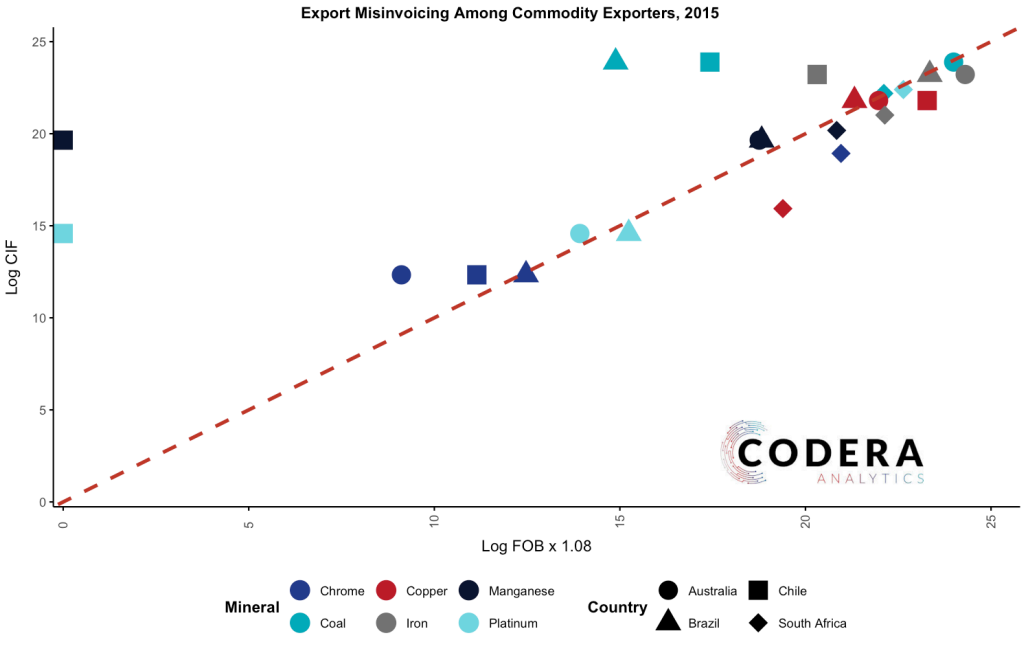
Comparing Tables 3 and 4, our estimates for revenue loss are relatively similar for coal, copper and manganese: for coal the two samples show around R5 billion of forgone revenue. Potential under-invoicing of copper ore exports, which is the smallest export commodity of the minerals in our study, is estimated to have implied R750 million of forgone tax lost over the decade in our unrestricted analysis, and just over R600 million after applying sample restrictions. For manganese, the restricted estimate was greater than the unrestricted estimate, with just under R4 billion estimated in the former case, and less than R2.5 billion in the latter. It should be emphasised that, although both unrestricted and restricted estimates provide some idea of how much revenue might have been lost from potential misinvoicing, the estimates are sensitive to which sample we use. Nevertheless, the magnitudes of our estimates hint at substantial losses to the fiscus if the data are representative, with our calculations pointing to billions of rands going uncollected in most of our commodity groups, even with transaction-level misinvoicining being undetected owing to aggregation.

6 Comparison to other countries

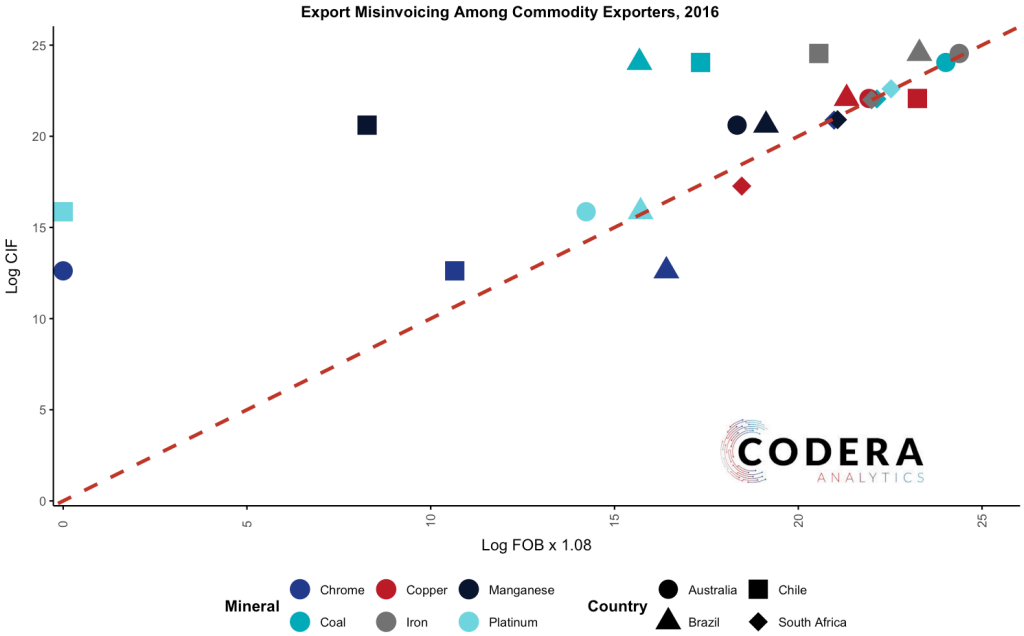
This section considers whether commodity misinvoicing might be unique to South Africa, or whether trade reporting imbalances are also observed for other countries. Below we plot the relationship between the CIF values (reported by the importing partner) and the adjusted FOB values (reported by each exporter, but increased by an shipping and insurance factor) to identify differences between reported trade values in the restricted sample. We plot CIF and FOB values for each of the six commodities in our study as reported by South Africa, Australia, Brazil and Chile over the sample period.

One would expect every commodity would sit on the 45-degree line (where adjusted FOB = CIF) if there were no misinvoicing and no data measurement issues. When commodities trade values diverge from this line, it flags potential trade misinvoicing or data anomalies. For example, Brazilian coal, Chilean coal and iron exports consistently suggest larger and more systematic under-invoicing over our sample than for South African exports. Although most values are near or slightly above the 45 degree line for most years, there are a couple of years in the sample characterised by over-invoicing for exports by some commodity exporters (or, under our assumptions, under-invoicing by importers). These include Brazilian Chrome exports in 2016 and 2017 and Chilean copper exports. While under-invoicing tends to be more common to avoid domestic taxes or shift profits abroad, over-invoicing could be motivated by export incentives or repatriation of illicit offshore funds.

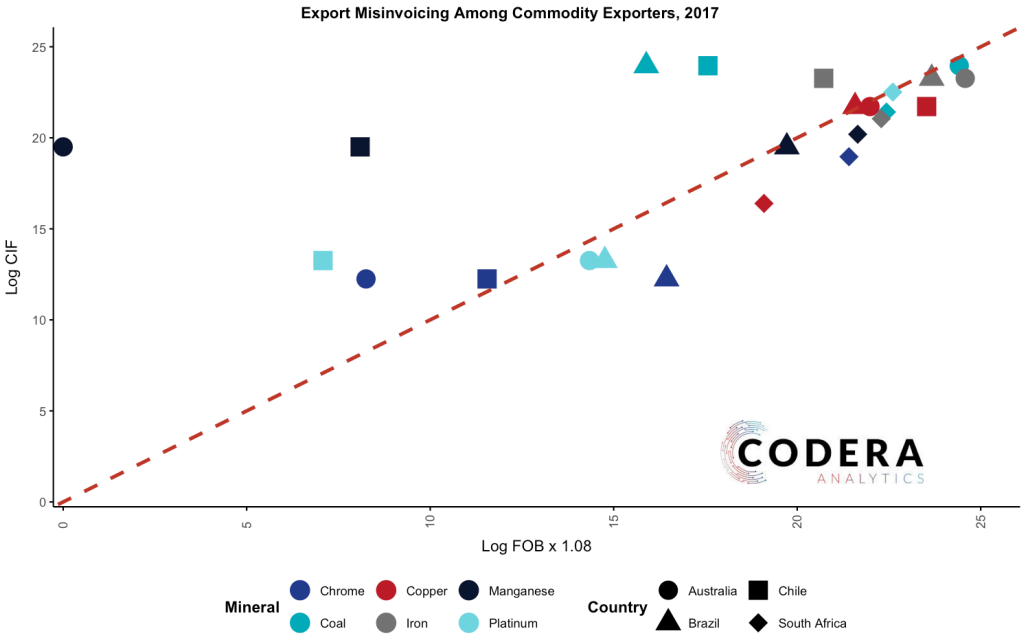
These charts also reveal that there are missing FOB values from the dataset for Australia and Chile commodity exports for several years in our sample (i.e. a zero x-axis value). It is important to keep in mind that commodities were selected based on the availability of South African data and that just as other countries reported zeros for certain goods, South Africa also has limited reporting on certain commodities, specifically gold. This indicates that trade data limitations are not unique to South Africa, but affect countries in general, compromising our ability to accurately measure trade flows. Lastly, the clustering of values around the 45 degree line suggests our use of a 8% CIF factor is a reasonable assumption.



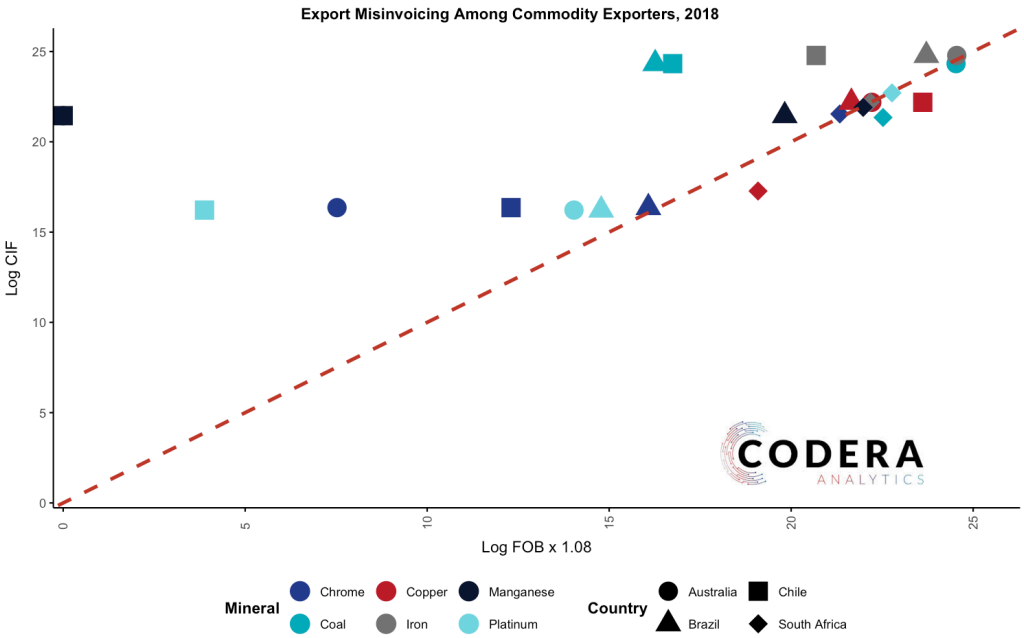
Source: UN Comtrade
Note: Current US Dollar values are multiplied by a CIF factor of 8% and then logged.



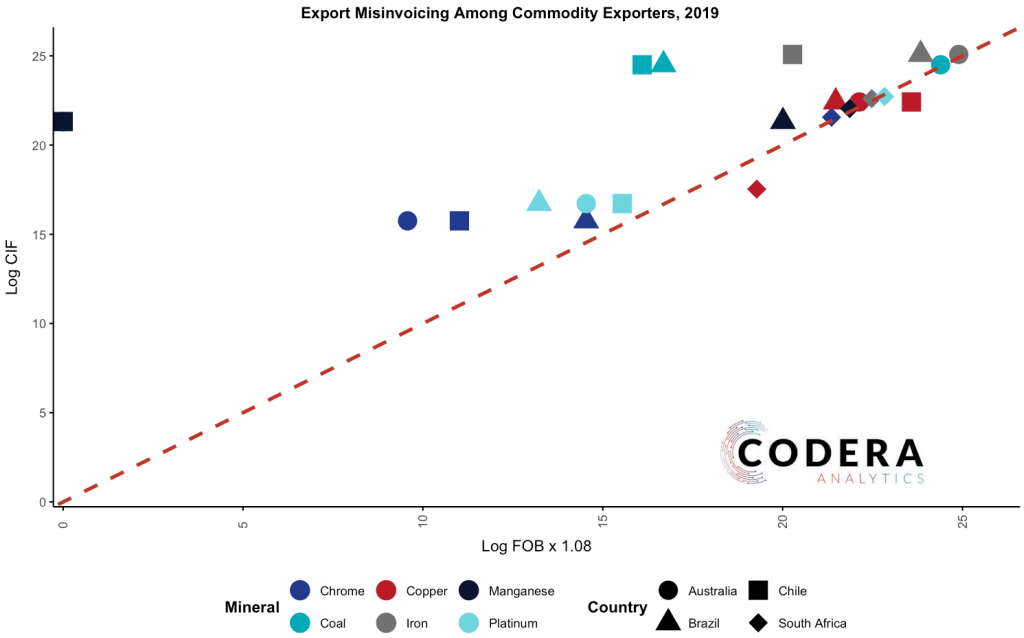
Source: UN Comtrade
Note: Current US Dollar values are multiplied by a CIF factor of 8% and then logged.



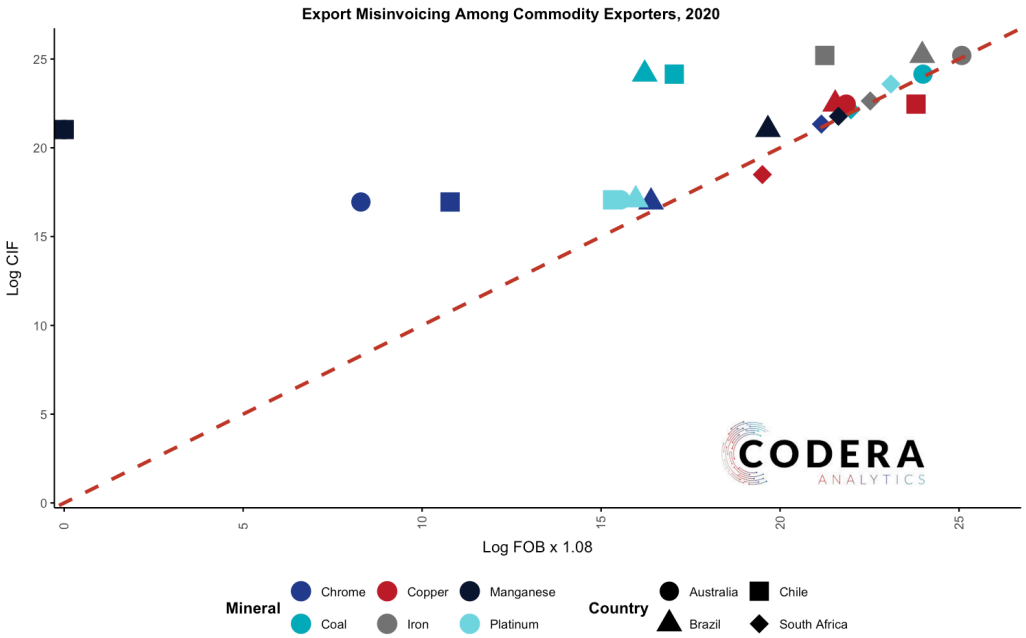
Source: UN Comtrade
Note: Current US Dollar values are multiplied by a CIF factor of 8% and then logged.



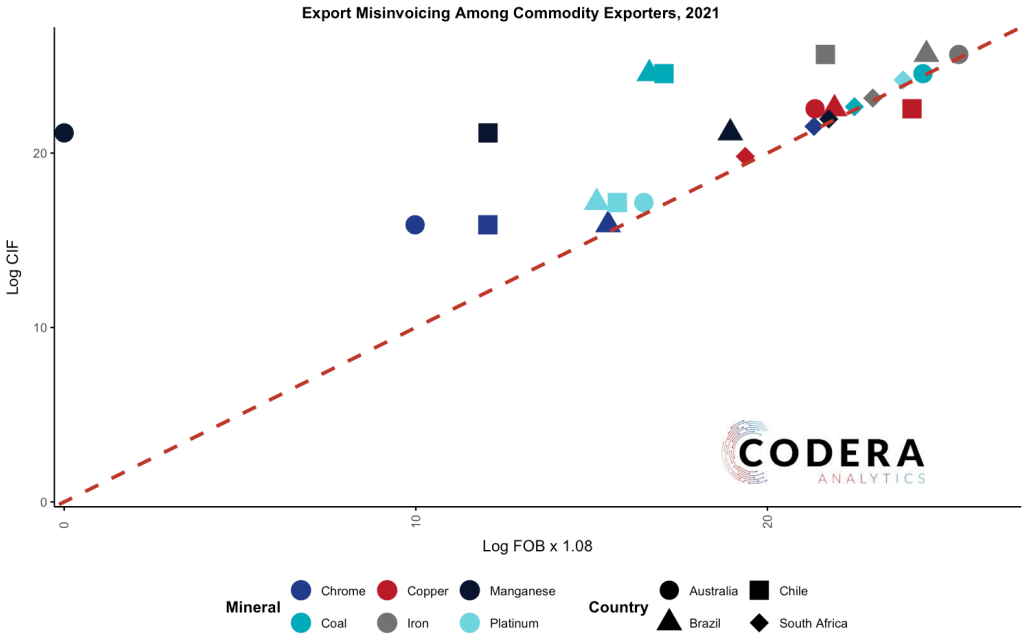
Source: UN Comtrade
Note: Current US Dollar values are multiplied by a CIF factor of 8% and then logged.



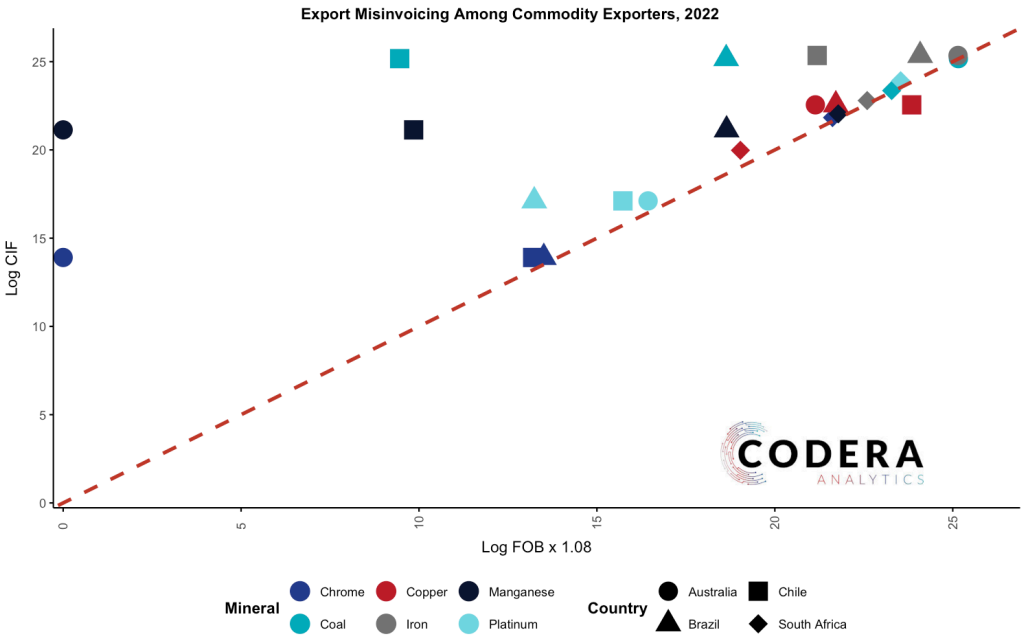
Source: UN Comtrade
Note: Current US Dollar values are multiplied by a CIF factor of 8% and then logged.



Source: UN Comtrade
Note: Current US Dollar values are multiplied by a CIF factor of 8% and then logged.



Source: UN Comtrade
Note: Current US Dollar values are multiplied by a CIF factor of 8% and then logged.



Source: UN Comtrade
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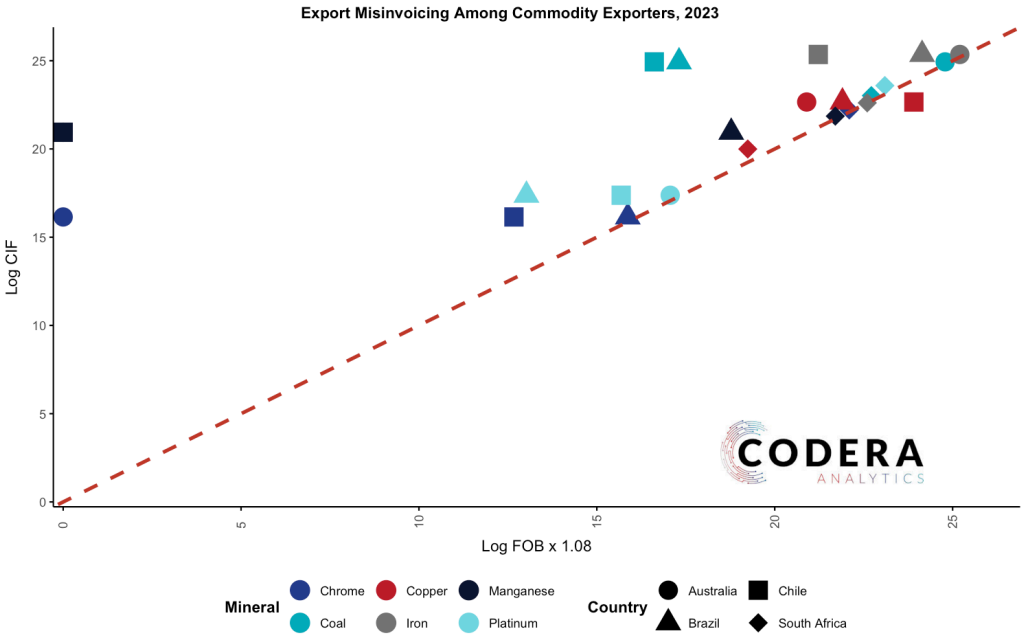

Source: UN Comtrade
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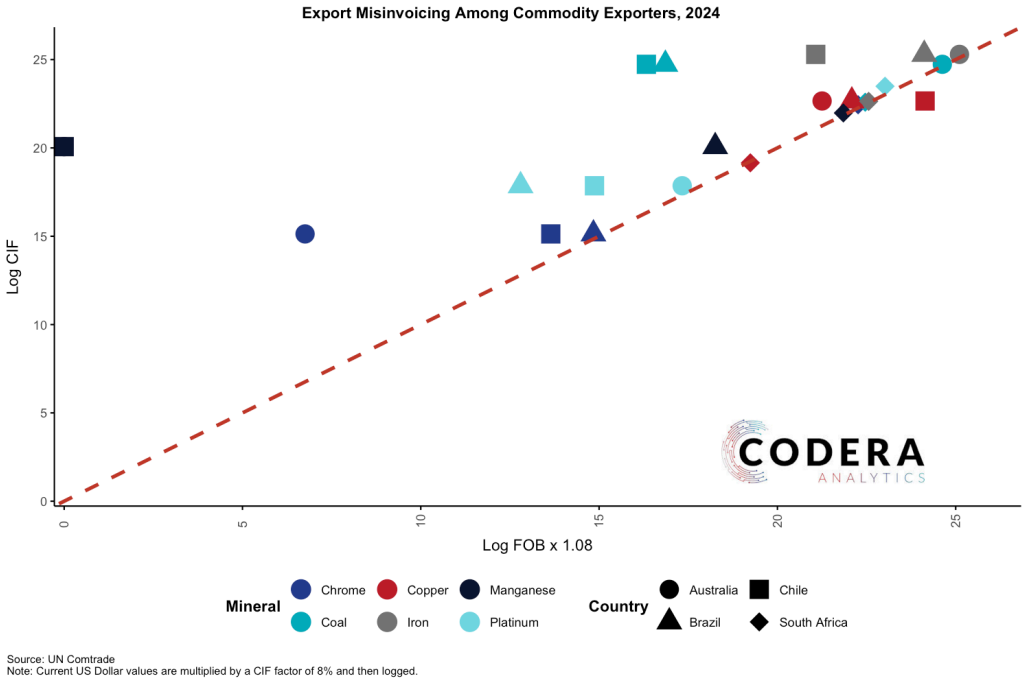

Source: UN Comtrade
Note: Current US Dollar values are multiplied by a CIF factor of 8% and then logged.

7 Conclusion

We quantify the extent of possible export misinvoicing in South Africa using publicly available data by comparing South Africa's reported export and global counterpart import data. On account of data limitations, we focus on mineral exports. We show that the data suggest that there has been systematic under-invoicing of South African commodity exports, but highlight a number of data quality issues. If taken literally, our findings suggests substantial foregone mineral royalties for the South African fiscus. Our back-of-the-envelope estimates range between R30 to R50 billion for the period 2015-2024. Across commodities, the degree of potential under-invoicing cannot be explained by exchange rate conversion differences or trade assignment to specific calendar years.

We highlight several data limitations that constrain accurate assessment of trade misinvoicing of South African trade. One issue with using aggregated data is that we can only identify under-invoicing when there is a net positive difference between total exports reported for a commodity to a country and the corresponding values reported for imports. As pointed out by Kar and Spanjers (2015), it is the gross value of trade that is of concern rather than the net value, as reversals from import under-invoicing do not result in additional revenue to the state. Unfortunately, data limitations prohibit undertaking more granular analysis. The lack of CIF data for South Africa prevents analysis of import misinvoicing as an mechanism enabling illicit financial flows. Additionally, the absence of detailed information on gold exports, South Africa's largest export category, prohibits the inclusion of the commodity in our study. Lastly, data availability for international services trade also constrains assessment of misinvoicing of services exports and intellectual property transfers.

The missing data problem is, however, not a problem unique to South Africa. Chinese Comtrade data is characterised by missing data for 2015 and 2017, while many countries report no exports when partner countries report imports for specific years. Another issue we highlight is incorrect designation of origin and destination owing to re-exporting. Given the data challenges we discuss, we recommend that future studies of trade misinvoicing and illicit flows consider matching transaction-level trade data across countries. Our estimates of foregone fiscal revenue suggest that investing in capacity to monitor trade misinvoicing would therefore

be self-funding.

8 Appendix

Table 5: Potential Chrome Misinvoicing, 2015-2024

Partner	Share (%)	CIF Value	FOB Value	Misinvoicing (%)
China	52	23 594 270 055	11 912 515 404	90
Mozambique	33	7 727	7 426 760 198	-108
Hong Kong	2	45 311	557 807 517	-108
European Union	2	513 613 618	546 316 749	-14
India	1	278 821 333	373 501 370	-33
Indonesia	1	1 221 580 131	324 405 055	269
Türkiye	1	393 350 019	294 733 724	26

Note: Misinvoicing equals the difference between CIF and FOB values (with an 8% CIF factor applied) as a percentage of the FOB value

Table 6: Potential Coal Misinvoicing, 2015-2024

Partner	Share (%)	CIF Value	FOB Value	Misinvoicing (%)
India	41	23 108 051 897	24 097 265 453	-12
European Union	14	10 004 926 380	8 433 849 460	11
Pakistan	9	5 968 225 880	5 579 055 649	-1
Rep. of Korea	8	5 654 458 547	4 722 701 372	12
Mozambique	3	105 637 242	1 906 251 102	-102
Sri Lanka	2	1 241 302 406	1 330 578 771	-15
Japan	2	1 638 190 896	1 181 616 361	31

Note: Misinvoicing equals the difference between CIF and FOB values (with an 8% CIF factor applied) as a percentage of the FOB value

Table 7: Potential Copper Misinvoicing, 2015-2024

Partner	Share (%)	CIF Value	FOB Value	Misinvoicing (%)
Mozambique	44	1 873 398	965 970 473	-108
China	36	1 435 132 956	797 625 912	72
Switzerland	13	1 111	284 649 965	-108
Rep. of Korea	2	174 104 423	45 436 945	275
Malaysia	0	84 302 905	10 619 171	686
Namibia	0	9 126 476	8 503 233	-1
European Union	0	52 239 655	7 393 483	599

Note: Misinvoicing equals the difference between CIF and FOB values (with an 8% CIF factor applied) as a percentage of the FOB value

Table 8: Potential Copper Misinvoicing (Incl. HS7402), 2015-2024

Partner	Share (%)	CIF Value	FOB Value	Misinvoicing (%)
China	62	5 311 165 711	3 032 802 410	67
Mozambique	20	2 113 081	970 238 035	-108
Switzerland	6	1 224	311 473 653	-108
Iran	3	0	132 060 101	-108
Rep. of Korea	2	276 893 140	98 981 940	172
European Union	2	162 940 621	96 412 948	61
USA	1	43 915 080	46 303 470	-13

Note: Misinvoicing equals the difference between CIF and FOB values (with an 8% CIF factor applied) as a percentage of the FOB value

Table 9: Potential Iron Misinvoicing, 2015-2024

Partner	Share (%)	CIF Value	FOB Value	Misinvoicing (%)
China	56	42 750 801 407	32 442 286 831	24
European Union	17	7 594 868 056	9 664 589 177	-29
Rep. of Korea	8	5 557 447 833	4 346 426 077	20
Mozambique	6	82 555 545	3 735 402 814	-106
Japan	6	4 207 035 161	3 493 335 611	12
India	2	881 649 138	1 356 916 351	-43
Türkiye	1	721 429 079	662 097 050	1

Note: Misinvoicing equals the difference between CIF and FOB values (with an 8% CIF factor applied) as a percentage of the FOB value

Table 10: Potential Manganese Misinvoicing, 2015-2024

Partner	Share (%)	CIF Value	FOB Value	Misinvoicing (%)
China	59	18 877 617 101	15 174 276 943	16
India	12	2 876 471 736	3 103 274 715	-15
Japan	5	1 498 084 974	1 295 393 468	8
European Union	4	711 193 657	1 079 554 876	-42
Malaysia	4	1 094 011 417	1 004 714 114	1
Norway	3	861 711 492	892 034 899	-11
Rep. of Korea	3	1 007 649 483	806 096 210	17

Note: Misinvoicing equals the difference between CIF and FOB values (with an 8% CIF factor applied) as a percentage of the FOB value

Table 11: Potential Platinum Misinvoicing, 2015-2024

Partner	Share (%)	CIF Value	FOB Value	Misinvoicing (%)
Japan	28	37 685 137 994	30 061 243 332	17
USA	26	31 103 576 169	27 908 445 632	3
United Kingdom	22	17 559 596 908	22 966 269 882	-32
European Union	9	14 123 719 376	10 007 278 219	33
Hong Kong	8	6 014 638 083	8 745 949 755	-39
Switzerland	3	1 813 301 482	3 052 716 023	-49
China	2	28 397 041 993	2 399 137 467	1076

Note: Misinvoicing equals the difference between CIF and FOB values (with an 8% CIF factor applied) as a percentage of the FOB value

Table 12: South African Exports of Platinum to China, 2015-2024

year	FOB Value	CIF Value	Misinvoicing (%)
2015	227039000	2288529824	908
2016	179277376	6553399253	3555
2017	69081921	1364964257	1876
2018	93647116	7277636598	7671
2019	41709846	7362279276	17551
2020	126372702	17592439131	13821
2021	707642206	32025667187	4426
2022	487846192	24366242641	4895
2023	197130510	17566364744	8811
2024	269390599	15906406735	5805

Note: Misinvoicing equals the difference between CIF and FOB values (with an 8% CIF factor applied) as a percentage of the FOB value

Table 13: Export Values from SARS vs Comtrade (USD Millions)

Year	Chrome	Coal	Copper	Iron	Manganese	Platinum
2015	1119	3517	238	3621	1008	6015
	1264	4010	264	4113	1125	6787
2016	1283	4151	1010	3516	1394	5953
	1285	4119	104	3564	1412	6060
2017	1993	5778	221	4795	2531	6587
	1987	5522	196	4789	2522	6570
2018	1871	6360	215	4322	3524	7779
	1846	6056	195	4273	3507	7746
2019	1900	4779	238	5823	3140	8250
	1890	4551	237	5787	3129	8252
2020	1519	3736	299	6621	2374	10734
	1541	3516	296	6031	2478	10738
2021	1829	6117	262	9890	2766	23231
	1824	5754	258	9719	2774	23055
2022	2409	13775	192	6347	2868	16826
	2454	12928	184	6500	2883	16645
2023	3917	7622	224	6516	2563	10713
	3941	7331	227	6532	2662	10713
2024	4619	6258	226	5903	2797	9975
	4663	5691	227	6276	3085	9924

Note: Top value is SARS, bottom value is Comtrade, in USD millions.
SARS values are converted from ZAR using monthly average exchange rates.
Source: Comtrade, SARS, Stratalyze, EconData, Codera Analytics

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