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

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Abnormal Pricing in International Commodity Trade: Empirical Evidence from Switzerland

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Executive Summary

Illicit financial flows (IFFs) pose a significant risk for tax base erosion in resource-rich, developing countries. Two prominent and overlapping channels for IFFs include trade misinvoicing and abusive transfer pricing. This paper aims to contribute new evidence by estimating the magnitude of abnormal pricing (defined as the magnitude of trade valued outside an assumed arm's length price range), for Swiss imports of gold, copper, cocoa, and coffee between 2011-17. Switzerland provides an important case study as one of the world's largest hubs for commodity trading companies, precious metals refineries, and ancillary services. Our baseline estimates rely on price filter analysis whereby transaction-level unit prices are compared to benchmark prices from commodities exchanges. As per the literature on illicit financial flows, abnormally undervalued imports indicate financial inflows while abnormally overvalued imports are interpreted as outflows. We compare these estimates with an interquartile range price filter based on observed price distributions calculated at the exporter country-year level. Finally, we also contrast these estimates with commonly used (and criticized) asymmetries in aggregate, mirror trade data.

Based on certain assumptions informed by qualitative research, price filter analysis reveals the following main results. Firstly, we find a significant magnitude of abnormally under-valued unwrought gold imports equaling CHF 82.2 billion (17% of total imports). Secondly, we prefer interquartile range price filter estimates for cocoa and coffee due to significant product heterogeneity and absence of internationally applicable, free-market benchmark prices. We find relatively small magnitudes of abnormally under-valued cocoa (CHF 44.7 million or 5% of total value) and coffee (CHF 128.9 million or 3% of total value) imports, i.e. exports priced in bottom quartile of the country-year price distributions. Furthermore, these estimates should be interpreted as indicative of the upper limit of abnormal pricing since the interquartile price range is endogenously defined. Finally, the aggregate mirror trade statistics demonstrate large asymmetries between Swiss imports and reported exports by trading partners, especially in the case of copper. We discuss various hypotheses to explain these observed patterns. In particular, we hypothesize that a '*Switzerland effect*' exists in international trade statistics driven by merchanting or transit trade by Swiss trading firms.

Overall, our analysis indicates economically significant estimates of abnormal pricing in Swiss commodity imports, despite some clearly discussed data limitations. These results reinforce the urgency to improve commodity data-recording standards to promote transparency and improve international trade governance, as well as to identify the regulatory loopholes and political economy dynamics driving trade-based illicit financial flows.

1. Introduction

Illicit financial flows (IFFs) from low-income and resource-rich countries have emerged prominently in contemporary debates about economic development, particularly in the context of challenges associated with increasing government revenues. IFFs are broadly defined as cross-border financial flows which are illegally earned, transferred or utilized (Forstater, 2018). This flight of financial capital leads to concerns regarding tax base erosion in the source countries. Tax revenues as a proportion of economic activity remain significantly lower across developing countries on average, compared to advanced economies.[1] Resource-rich developing countries are particularly concerned about the erosion of their domestic tax base through commodity trade-related IFFs, since they generate a significant share of their public revenues from the production and sale of mineral and agricultural commodities. According to International Monetary Fund's (IMF) research on ten mineral-rich countries, mining's share of total government revenue was 11% on average, with a maximum of 40% for Botswana (IMF, 2017). Therefore, effective taxation of mining sector is critically important to domestic revenue mobilization, especially in developing countries that comprise 63 of the top 70 mining countries by contribution of the sector to the economy (Readhead, 2018; International Council on Mining and Metals, 2014). Similarly, while the share of agricultural exports continues to decline in developing countries, the share of horticultural, processed, and semi-processed agricultural commodities has increased. Accordingly, there is an increased focus on prioritizing policies to promote revenue generation through high-value agricultural commodity production (Fukase & Martin, 2017).

The existing literature has identified two overlapping channels for commercial actors to transfer financial capital across national boundaries: trade misinvoicing and intra-firm transactions of multinational firms.[2] Trade misinvoicing is defined as a form of customs and/or tax fraud involving exporters and importers deliberately misreporting the value, quantity, source, destination, or nature of goods or services in a commercial transaction. The economic motives include tax-motivated profit shifting and evasion of customs duties or trade restrictions on particular commodities or countries. Developing countries often lack the tax administration and customs valuation capacities required to

[1] According to the OECD's Global Revenue Statistics Database, tax revenue-to-gross domestic product ratios in year 2015 displayed considerable heterogeneity between and within regions, between 10.8% to 30.3% in Africa and 12.4% to 38.6% in Latin America, compared to 16.2% to 45.9% in the OECD countries. See: Modica, Laudage, & Harding (2018).

[2] This paper focuses on IFFs resulting from business and financial practices of legally established business entities involved in international trade, as opposed to the illegal cross-border activities of criminal groups which may include smuggling and money laundering. There is an important, ongoing debate regarding whether intra-firm financial practices used to shift capital between different legal jurisdictions should be included in the definition for IFFs. We address this debate over concepts and definitions in Bonanomi and Musselli (2019) and Mehrotra (2019).

monitor complex tax avoidance techniques used by multinational enterprises (MNEs). For example, MNEs may establish local subsidiaries in developing countries that sell their production to affiliated marketing or purchasing companies. These local subsidiaries also receive finance, services, and equipment from either the parent or related companies. The process of determining the value of these transactions is called transfer pricing. As per normal business practice, the terms and pricing conditions of transactions between related parties should be comparable to arm's length terms and prices, i.e. conditions under which the transaction would have taken place between unrelated parties. However, abusive transfer pricing occurs when related parties distort the price of a transaction outside an arm's length value to shift profits to lower-taxed jurisdictions and thereby reducing the MNE's overall tax bill. Mispricing of commodities exported and transferred to related parties is therefore one of the main transfer pricing risks related to international commodity trade (Readhead, 2018).

Available statistical evidence on measurement of trade mispricing is generally limited to macroeconomic studies of partner-country trade gaps or asymmetries in aggregate export and import statistics of trading partners (Global Financial Integrity, 2017; Ndikumana, 2016). The methodologies used in these studies have some important limitations due to which their large estimates of trade mispricing are generally considered weak evidence of cross-border financial flows. A few studies have used transaction-level trade data to analyze trends of abnormal pricing at the commodity level; however this evidence generally remains limited due to administrative restrictions on public access to transaction-level Customs data (Hong & Pak, 2017; Hong, et al. 2014; Zdanowicz, et al. 1999).

1.1. Research Objectives

This paper aims to contribute to the IFF literature by estimating the magnitude of abnormal pricing, i.e. magnitude of trade valued outside arm's length range, for Swiss commodity imports from the rest of the world. As per the literature on trade-based illicit financial flows and trade misinvoicing, under-valued imports are interpreted as evidence of illicit inflows of financial capital into the importing country. On the other hand, over-valued imports are interpreted as evidence of illicit financial outflows whereby financial capital leaves the importing country through the trade channel.

Similar to Hong et al. (2014), our baseline analysis is based on free-market price filter analysis whereby transaction-level prices are compared to global benchmark prices from commodities exchanges or trading associations. The empirical methodology is motivated by the Comparable Uncontrolled Price (CUP) method for establishing the arm's length price range for commodities

using commodities exchange prices, as per global transfer pricing guidelines (OECD, 2017; Platform for Collaboration on Tax, 2017; United Nations, 2017).[3] The CUP method allows the use of quoted market prices as a starting point for identifying arm's length prices, subject to reasonable comparability adjustments, after having accurately delineated each transaction based a fact-intensive transactional and functional analysis on a case-by-case basis.[4] However, for this statistical analysis of a large number of international transactions, some standardized assumptions regarding product heterogeneity, market conditions and transportation costs are adopted to broadly define an arm's length price range. These assumptions are discussed in detail and sensitivity analysis is also provided to test the robustness of empirical estimates.

Next, we compare these abnormal pricing estimates with endogenously calculated interquartile range (IQR) price filters. The IQR price filter assumes that the price range between the 25th and 75th percentile of observed prices represents an arm's length price range. According to Hong et al. (2014), this method is motivated by the United States Internal Revenue Service (IRS) transfer pricing regulation (Internal Revenue Code 482) which specifies that an interquartile range is an acceptable arm's length transaction range. The OECD Transfer Pricing Guidelines also mention that interquartile range or other percentiles can be used to help enhance the reliability of any transfer pricing analysis (paragraph 3.57, OECD, 2017). To operationalize this method, we calculate the interquartile range of unit prices by product, source and year, i.e. for all Swiss import transactions of a particular commodity from a source country in a given year. Any transactions which are valued in the top and bottom quartile of this price distribution are designated to be abnormally priced. The interquartile range price filter method is especially useful to consider in the case of commodities which are traded without a clear reference to benchmark prices from commodities exchanges. The resulting estimates should however be carefully interpreted and combined with contextual knowledge regarding commodity and market characteristics, since there could be legitimate business reasons for significant price fluctuations in individual markets.

Finally, the price-filter estimates are compared to the asymmetries observed in aggregate, product-level data to contrast the micro-evidence with the more commonly used aggregate empirical

[3] The use of prices from commodities exchanges for transfer pricing analysis is also referred to as the 'sixth method' in some countries, which is distinct from comparable uncontrolled prices (CUP) method which relies on data from comparable transactions between related and unrelated parties. See Section 2.4.2, United Nations (2017) for a detailed discussion of the 'sixth method.'

[4] The case by case transactional and functional analysis may include the specific contractual terms of the individual transaction; the functions performed by each of the parties to the transaction, their account assets used and risks assumed; the individual characteristics of the transacted good; the specific market conditions in which the parties operate, including their relative competitive position; the business strategies pursued by the parties, etc. For the list of criteria used to delineate the economically relevant characteristics for transfer pricing analysis, see: Chapter 1-D1, OECD (2017).

methodologies, or partner-country trade gaps. According to this method which relies on the principle of double counting in international trade statistics, the reported trade values of the developed or industrialized trading partner are used as the arm's length value for the trade statistics of the developing country trading partner. We specifically test whether the broad patterns of results are consistent across methodologies, but acknowledge that partner-country trade asymmetries have important limitations as estimates of trade misinvoicing due to concerns related to product heterogeneity, data availability, and reporting standards.

Our analysis is based on transaction-level imports data from Swiss Federal Customs Administration on two extractive (gold and copper) and two agricultural commodities (coffee and cocoa beans) for the micro-data analysis for the period 2011-17. Meanwhile, the aggregate trade-gap analysis is based on product-level annual exports and imports data from the United Nations (UN) Comtrade database. We clearly discuss the limitations associated with these data and methodologies, while also applying some methodological innovations to address them.

1.2. Main Findings

Our main findings are as follows. Firstly, we observe economically significant estimates of abnormal pricing in unwrought gold imports. The value of underpriced gold imports, defined as import transactions valued below 40% of contemporaneous free market prices, is equal to CHF 82.2 billion, which corresponds to 17% of the total value of unwrought gold imports during the period 2012-17. We utilize a 40% price filter around the London Bullion Market Association (LBMA) daily gold price series based on certain clearly discussion assumptions informed by commodity sector research.[5]

The trade microdata for gold is however limited in terms of two specific factors. We assume our analysis to be based on unwrought gold doré bars imported by Switzerland for refining, which usually contain over 70% of pure gold, mixed with silver, copper, or other base metals. However, the Customs product classification for unwrought gold also includes gold alloys with up to a minimum of 2% of pure gold, mixed with silver, copper or other base metals.[6] The share of pure gold in each transaction is not recorded by Customs data, so we are unable to account for the share of unwrought

[5] These assumptions are discussed in Section 4.
[6] See: Chapter 71, section 5.b., Swiss Federal Customs Administration List of Tariff Headings - https://www.ezv.admin.ch/ezv/en/home/information-companies/customs-tariff---tares.html (accessed: Feb, 2018)

gold transactions which are predominantly other precious metals, i.e. platinum or silver.[7] As a result, our estimates for abnormally under-valued gold imports should be interpreted as an upper limit and we highlight the importance of recording this information in our policy recommendations.

Furthermore, the product category for unwrought gold imports may also include transactions of small gold ornaments shipped to Swiss refineries for gold extraction. To account for these small shipments, we exclude 2,854 transactions (5% of total transactions) of non-industrial amounts, defined as less than 1 kilogram by weight. However, this does not have any material impact on our estimates of abnormal valued gold imports.

Overall, we conclude that the magnitude of abnormally under-valued unwrought gold imports remains very significant despite allowing for these limitations. Improved data recording practices may have allowed us to account for imports of other precious metals, i.e. silver or platinum, which are mis-classified as gold. However, it remains hard to argue whether this practice would account for the entire estimate of CHF 82.2 billion of abnormally under-valued unwrought gold imports, especially since the other metals in such alloys are also highly valuable commodities driving the transaction prices upward. The magnitude of this result highlights the urgency to identify the economic incentives, political economy dynamics and regulatory loopholes which drive the phenomenon of trade-based illicit financial flows, while also highlighting the need for improved data recording practices.

Secondly, in the case of both agricultural commodities, we note that free market price filter analysis is more complicated due to significant product heterogeneity which leads to the absence of an internationally recognized market reference price. Coffee and cocoa bean exports from different sources are traded at significantly different price levels, reflecting differences in quality, production and processing costs, local commodity sector governance, as well as other market-specific conditions. As a result, we prefer interquartile range price filter estimates of abnormal pricing for cocoa and coffee imports. We improve the applicability of this methodology to local market conditions by calculating the interquartile range by product, source and year, i.e. for all Swiss import transactions of a particular commodity from a source country in a given year. Since the interquartile price range is endogenously defined, this method designates some transactions to be abnormally over and under-valued. Therefore, these estimates should be interpreted more carefully and treated as the upper limit of abnormally valued imports to Switzerland.

[7] Since refined gold bullion, coins, and unprocessed gold imports meant for refining are also exempt from value added taxes in Switzerland, there is an additional incentive for importers to classify other precious metal alloys as gold in their Customs declarations. See: Article 44 of the Ordinance on Value Added Tax issued by the Swiss Federal Council in 2009.

Our results show relatively minor magnitudes of abnormally under-valued imports, equal to CHF 44.7 million for cocoa beans (5% of total import value) and CHF 128.9 million for coffee beans (3% of total import value) between 2011-17. Therefore, we conclude that the phenomenon of abnormally under-valued imports is relatively minor, but not insignificant in agricultural commodities. We also observe comparatively small magnitudes of over-valued coffee and cocoa bean imports to Switzerland, equal to 1% of imports for cocoa and 2% of imports for coffee between 2011-17. In section 5, we discuss whether these estimates can be partially explained by Swiss importers' demand for high-quality or premium agricultural commodities for domestic consumption and production of luxury consumer food products. In the case of cocoa beans, we also observe evidence of fixed pricing agreements whereby import prices remain constant at a certain price level and do not deviate with contemporaneous market prices.

Finally, we also consider partner-country trade gaps using mirror statistics from Switzerland and its trading partners. The annual product-level data highlights the presence of large asymmetries in reported Swiss imports of the selected commodities versus the exports to Switzerland reported by the rest of the world. These annual trade gaps are systematically positive for gold, cocoa, and coffee indicating that reported Swiss imports exceed what the rest of the world reports as exports to Switzerland. These gaps provide weak evidence of trade misinvoicing due to significant limitations in the aggregate data, including missing exports data and different recording practices used by different countries.

However, it is interesting to note that these trade gaps are systematically negative for copper indicating the opposite phenomenon. We hypothesize that a '*Switzerland effect'* exists in international trade statistics of copper driven by the merchanting activities of Swiss-based trading firms. The exporters record Switzerland as the destination for their copper exports in their trade statistics since they are selling to Swiss trading firms, however these firms store and trade the commodity to a third country instead of importing the physical commodities into Switzerland. These hypotheses are partially supported by the findings of other researchers using Customs data from producer countries, especially in the case of Zambian copper exports (Brulhart, et al. 2015).[8]

In conclusion, it is important to note that the abnormal pricing estimates based on price-filter analysis should be interpreted as strongly indicative, but not as precise, causal evidence of Customs fraud and abusive transfer mispricing. Since our data sources are completely anonymized, we are

[8] The authors find that Swiss copper imports from Zambia were approximately 6,000 times smaller than reported Zambian exports to Switzerland, which can be linked to the fact that most of the copper was being purchased by Swiss trading firms for re-sales to a third country.

unable to distinguish between related or unrelated party transactions. Trade micro-data also does not record details regarding the quality of each commodity shipment. As a result, price-filter analysis has some limitations related to the estimation methods as well as the commodity characteristics, which we discuss in Section 2. Furthermore, there are a number of characteristics of commodity trading sector due to which the value of individual transactions may lie outside the arm's length price range determined by either contemporaneous free-market prices or interquartile price ranges. For extractive minerals like gold and copper, there can be significant heterogeneity in extraction costs and purity levels that are not explicitly recorded in trade micro-data. In addition, both minerals and agricultural commodities like cocoa and coffee are often stored in raw, semi-processed or processed forms until price arbitrage opportunities arise for commodity traders. Finally, some combination of all these issues is expected to be reflected in the case of Switzerland, which is a major commodity trading hub that trades selected commodities with a large number of producers and consumers, as well as other shipping and trading hubs.

Specific cases of abusive transfer pricing or trade mispricing may be determined on the basis of using such evidence to identify and conduct an investigation into the pricing practices of specific actors engaged in abnormally priced commodity trade. We will therefore aim to conduct further empirical and qualitative research to improve our empirical estimates. In related work, we also apply these methods to single-country export micro-data that is expected to demonstrate significantly lower heterogeneity in extraction costs and trading practices (Nolintha, et al, (2019) for Laos; Ahene-Codjoe, et al. (2019) for Ghana).

2. Background: Swiss Commodity Trading Sector

We focus on Switzerland given its status as one of the world's largest commodity trading and financial hubs. Eggert, et al. (2017) used data from the Swiss Trading and Shipping Association to identify 496 firms with core interests in commodity trading or related activities concentrated in three regions: the Lake Geneva region (Geneva and Vaud), central Switzerland (Zug), and Lugano (Ticino). According to the STSA, the sector employs over 13,000 people directly and generates a further 20,000 jobs indirectly in Switzer-land. The estimated share of global trade in major commodities handled by Swiss firms includes: 35% of Cocoa, 60% of Metals, 35% of Oil, 60% of Grains, 50% of Sugar, and 50% of Coffee.[9] A reconciliation of production, trade, and consumption

[9] Source: STSA Website https://stsa.swiss/

data on sixteen major energy, extractive, and agricultural commodities by Jungbluth & Meili (2018) also corroborates that Swiss trading companies manage between 20 to 65% of global trade depending upon the commodity.

Switzerland is also an important precious metals processing hub due to presence of four large precious metal refineries accredited by the London Bullion Market Association's Good Delivery List.[10] According to the United States Geological Survey (USGS) data for 2017, the global mine production of gold equaled 3,150 tons while Swiss Customs data indicates that 2,385 tons of unwrought gold was imported into the country (in addition to a relatively negligible 133 kilograms of gold ore and concentrate).[11] This implies that Swiss refineries and trading firms imported unwrought gold equal to 75% of global annual production in 2017, making it the dominant global hub for gold trade. Finally, Switzerland is also one of the world's largest financial services hub which provides trading firms with vital trade-finance, insurance, logistics, and legal services. This agglomeration of complementary industries is governed by Swiss federal and cantonal regulatory frameworks. Trading companies are subject to an auxiliary status with a tax rate of approximately 11.6% in Geneva, with similarly favorable fiscal rates in other Swiss cantons. Favorable regulatory environment and political and economic stability are also considered important for this industry (Eggert, et al. 2017).

Despite the size and significance of the Swiss trading sector for understanding international commodity trade, empirical analysis of this sector is complicated due to certain business characteristics and limitations in data coverage. Firstly, Swiss trading firms' predominant activities are transit or merchant trade, whereby the products are bought and sold outside Swiss Customs territory. Information on transit trade is therefore not available in Swiss Federal Customs Administration statistics which only records transactions which physically enter the territory. The Swiss National Bank (SNB) publishes aggregate data on merchanting in the balance of payments (BOP), however this only provides a rough approximation of the magnitude of commodity trading activities since it includes trade in commodities, pharmaceuticals, and chemicals, in addition to net costs of services associated with transit trade including storage, insurance, and processing. Systematically collected firm-level financial and operational statistics on the sector remains publicly unavailable. The Swiss classification of industries (NOGA) does not have any dedicated category for the trading sector, while most companies are privately held and their financial data is considered sensitive due to the highly competitive nature of the sector. As a result of these limitations, we focus our analysis on the available trade micro-data from Swiss Federal Customs Administration. While this data does not

[10] The list certifies refineries that meet the stringent production quality criteria. For more details, see: http://www.lbma.org.uk/good-delivery-list-about

[11] Global statistics on gold production available here: https://minerals.usgs.gov/minerals/pubs/commodity/gold/

account for merchanting, it can be expected to shed light on pricing patterns of physical trade which enters Swiss Customs territory.

3. Empirical Methodologies

International trade data is of great economic interest for many reasons. Trade in goods and services have significant effects on a country's economic activity, while contributing a significant share of government revenue through Customs duties. Researchers have also shown that trade data can be used to study corruption, capital flight, and trade misinvoicing, which includes mispricing of transactions. As discussed in the previous section, mispricing of commodity trade transactions is a prominent channel for IFFs from resource-rich developing countries. It refers to the practice of exporting firms understating their trade values on Customs invoices, or importers overstating their import expenditures, with the motivation of transferring financial capital abroad either for private gain or for reducing corporate tax liabilities. In order to quantify the magnitude of this phenomenon, researchers have analyzed asymmetries in partner-country trade statistics or examined pricing anomalies in transaction-level data. In this section, we discuss two prominent methods used to estimate trade mispricing, including partner-country trade analysis method introduced by Bhagwati (1964) and Bhagwati, et al. (1974), and the price-filter analysis methods introduced by Zdanowicz, Sullivan, & Pak (1999) and Hong, et al. (2014), alongside a brief discussion of their limitations.

3.1. Partner-Country Trade Gap Analysis

Partner-country trade gap analysis is the predominant approach used in the policy and advocacy literature for quantifying the extent of trade misinvoicing (Global Financial Integrity, 2017). Bhagwati (1964) and Bhagwati, et al. (1974) provided the first analysis based on partner-country trade gaps including a discussion on the incentives involved for trading firms, especially focusing on tax and customs duty evasion. This methodology is based on the principle of double-counting in international trade statistics, whereby the exporting country's statistics are compared to the importing partner's corresponding statistics, i.e. mirror statistics. It is further assumed that advanced countries' trade statistics are reliable and that any unexplained asymmetries in reported trade statistics between advanced and developing trading partners is evidence of trade misinvoicing in developing countries. In other words, the trade statistics of the advanced country represent the arm's length value for the exports and imports of developing countries.

Accordingly, the partner-country trade gap method tests the following hypothesis:

> ***Hypothesis:*** *The export and import values reported by developing countries should equal the corresponding trade values reported by their industrialized trading partners after accounting for transportation and insurance costs.*

If the trade statistics reject this hypothesis, the corresponding gaps between the partners' mirror statistics are interpreted as evidence of trade misinvoicing in developing countries. This method is implemented as follows: first, annual import data (measured using cost plus insurance and freight or c.i.f. method) are converted to the free-on-board basis using a standard factor of 10 percent used by the IMF's Direction of Trade Statistics (DOTS). Next, the import and export discrepancies (I.D. and E.D., respectively, as denoted below) are calculated using the following formulae:

$$\mathbf{ID_{j,p,t} = I_{jt} \,/\, r - X_{p,t}}$$

$$\mathbf{ED_{j,p,t} = I_{p,t} \,/\, r - X_{j,t}}$$

where:

$\mathbf{I_{j,t}}$ = Imports by country *j* from the partner country *p* at time *t*

$\mathbf{I_{p,t}}$ = Partner country *p*'s imports from the country *j* at time *t*

r = Standard freight and insurance cost adjustment factor of 10 percent

$\mathbf{X_{p,t}}$ = Partner country *p*'s exports to country *j* at time *t*

$\mathbf{X_{j,t}}$ = Country *j*'s exports to partner country *p* at time *t*

These discrepancies or trade gaps are usually calculated at the aggregate level, including all traded product categories, but they can also be calculated at the product level (based on the Harmonized Commodity Description and Coding System or HS code) subject to availability of disaggregated data. Most recent applications of this approach include the empirical literature on IFFs conducted by advocacy organizations and policy institutions.

Methodological Limitations of Partner-Country Trade Gaps: The large estimates of trade-based IFFs generated using this methodology have been critiqued by a number of academic studies (De Wulf, 1981; K. P. Hong & Pak, 2017; Nitsch, 2016; Reuter, 2012). In their latest report, Global Financial Integrity (2017) acknowledges these limitations which can be briefly summarized as follows:

1. **Incorrect to assume that trade statistics in advanced economies exhibit no asymmetries:** The main underlying assumption of is to consider advanced economies' trade statistics as arms-length values for comparison with developing countries' trade statistics. However, Hong and Pak (2017) use both transaction-level trade data from Customs agencies and aggregate trade statistics from the IMF DOTS database to show that significant asymmetries also exist in mirror statistics of trade between advanced economies, thereby making it hard to justify this crucial assumption.

2. **Unobserved trade costs:** Import transactions are valued on a cost, plus insurance and freight (CIF) basis which must be artificially to the free-on-board (FOB) valuation conventionally used for exports before trade gaps can be calculated. Since data on transactions costs of trade are not generally recorded, a 10% rule-of-thumb adjustment has been used for these conversions. This rule of thumb is derived from aggregate differences between global export and import values. Therefore, a standard 10% estimate of trade costs has limited applicability for reliably converting bilateral trade values across all commodities with varying shipping and insurance costs.

3. **Use of aggregate trade statistics:** A majority of this literature focuses on calculating aggregate trade gaps, using total annual exports and imports figures. However, in many cases, bilateral data between trading partners may not be available for all goods and commodities being traded leading to the generation of highly misleading estimates of trade gaps. Furthermore, aggregate trade gaps can mask under or over-invoicing in particular commodities which cancel out in the aggregate.

4. **Exports and import transactions can be recorded in different years:** Depending upon the mode of transport and distance between trading points, international trade can take significant time to complete. This could lead to partners often recording the same transaction in different years, while the annual trade gaps are calculated using statistics for the same year.

5. **Entrepôt trade:** For several commodities, the source and destination countries recorded in the statistics reflects reporting from intermediate ports where the shipment is warehoused for a time before being shipped to the ultimate destination in other countries. Furthermore, international commodity trading firms can decide to divert shipments in transit to storage warehouses to benefit from arbitrage opportunities when market prices fluctuate. When exports and imports passing through these entrepôt ports are reported by both the entrepôt countries and the

exporting-importing partners, this leads to double-counting in official data and generation of artificial trade gaps.

6. **Exchange rates used for currency conversion:** International trade transactions can be conducted either in certain vehicle currencies (e.g., the U.S. dollar) or in local currencies. If different exchange rates are used by trading partners to convert their trade values to USD, this can lead to gaps in their mirror trade statistics. Some developing countries can also maintain multiple exchange rate regimes, thereby amplifying the possibility for such errors.

7. **Country idiosyncrasies:** Any international estimation of trade gaps can also be affected by particular countries who do not report bilateral trade flows for particular goods for particular years for one reason or another. For example: Switzerland is a major destination for gold refining, however it did not report disaggregated, country-level data on its international trade in unwrought gold until 2012.

3.2. Price-Filter Analysis

Price filter analysis is an alternative methodology proposed by Simon Pak and his co-authors to analyze abnormal pricing in international trade. This methodology relies on a single country's transaction-level trade microdata on product-type (based on the Harmonized Commodity Description and Coding System or HS code), quantity, and unit value. This data is used to identify the arm's length price range for individual products which is then used to distinguish between normally and abnormally priced transactions. There are two main approaches to applying price filter analysis which are presented below.

Inter-quartile range price filter: This methodology assumes that the inter-quartile range, between the 25th and 75th percentile, of the observed distribution of unit prices for a particular commodity represents the arm's-length price range. Under this approach, the overpriced amount is assumed to be the deviation of the price from the upper-quartile price when a declared unit value (price) is above the upper-quartile price. Similarly, when a declared price is below the lower-quartile price, the underpriced amount is assumed to be the deviation of the price from the lower-quartile price.[12]

[12] According to Hong et al. (2014), this approach is based on the United States' Internal Revenue Service (IRS) transfer pricing regulation, Internal Revenue Code 482, which specifies that an interquartile range is an acceptable arm's length transaction range.

Essentially, we test the following hypothesis using the interquartile range price filter method:

> ***Hypothesis:*** *The transaction price for a correctly valued product lies within the arm's length price range defined by the interquartile range of the observed price distribution.*

Accordingly, any transaction value which exceeds the 75th percentile or fall below the 25th percentile of the observed price distribution is designated to be abnormally priced. The under or over-valued amounts for each transaction is then calculated as follows:

$$\text{Undervalued amount} = \text{Quantity} \times \text{MAX}(0, \text{LoQ} - \text{P})$$
$$\text{Overvalued amount} = \text{Quantity} \times \text{MAX}(0, \text{P} - \text{UpQ})$$

where:

P = Declared price (unit value implied in quantity and value in each trade record)
LoQ = Lower-quartile price
UpQ = Upper-quartile price

It is relatively straightforward to observe that since the interquartile price range is endogenously estimated using the observed price distribution, this hypothesis will be rejected by design for a certain proportion of transactions. Therefore, these estimates of trade mispricing should be interpreted carefully and supplemented with further analysis regarding product, price, and individual market characteristics. For example, the level of purity of a precious metal and any contemporaneous political, economic or environmental shocks may play a key role in determining whether the observed transaction price falls within the interquartile price range during a given period. We discuss these limitations in more detail below.

Free-market price filter: This framework compares actual transaction-level unit prices for a particular commodity with their contemporaneous free-market price, plus/minus an assumed range of deviation to account for expected price volatility due to product characteristics, transportation costs, contract terms, and business conditions. This range is assumed to represent the arm's length price range for the particular traded product. All transaction prices within this price range are assumed to be normally priced, while any prices outside the range as designated to be abnormally priced.

More specifically, we test the following hypothesis by applying this method:

Hypothesis: *All normally valued transaction prices for a particular product fall within the arm's length price range defined using the corresponding free-market prices.*

The abnormally overvalued amount is estimated as the deviation from the upper bound of the range (P_{High}) and the abnormally undervalued amount as the deviation from the lower bound of the range (P_{Low}). Specifically, the mispriced amount for each transaction is calculated as follows:

$$\text{Undervalued amount} = \text{Quantity} \times \text{MAX}(0, P_{Low} - P)$$
$$\text{Overvalued amount} = \text{Quantity} \times \text{MAX}(0, P - P_{High})$$

where:

P = Declared price (unit value implied in the quantity and value in each declared import record)
$\mathbf{P_{Low}}$ = Lower bound of the free market price range
$\mathbf{P_{High}}$ = Upper bound of the free market price range

The main advantage of using the free-market price filter method is that we do not need to endogenously estimate arm's length price using the observed transaction prices. Therefore, this method is not affected by related party transaction records in the import and export database. However, this method requires easily identifiable and commonly acknowledged benchmark prices which may not be readily available for products where there is no established commodity market.

Methodological Limitations of Price-Filter Analysis: According to Reuter (2011) and Carbonnier & Zweynert de Cadena (2015), price filter analysis based on trade micro-data is an intuitive methodology, however it has some important limitations in accurately estimating abnormal pricing:

1. **Endogeneity of the interquartile range price filter:** For defining the interquartile price range, the lower- and upper-quartile bounds are estimated based on observed trade transactions. Therefore, as long as there is at least some variation in prices within each commodity, this method will always produce some overpriced and underpriced transactions. Furthermore, the occurrence of statistical outliers, potentially due to human recording errors, may lead to a reclassification of transactions from normal to abnormally priced and vice versa.

2. **Potentially disproportionate impact of related party transactions:** Without specific information on the trading firms, price filter analysis cannot distinguish transactions between related or unrelated entities. This implies that if international trade in a particular commodity is

dominated by related parties with an incentive to deviate from arm's length prices, the estimated interquartile range may be biased.

3. **Product heterogeneity:** Price filter analysis is usually based on product classification at a high level of disaggregation. However, for products which are very heterogeneous in terms of quality and prices, this method can still incorrectly identify high-end products as overpriced and low-end products as undervalued. Meanwhile, abnormally priced transactions of mid-range products might be wrongly classified as legitimate transactions.

4. **Limitations in international commodity classification system:** While most traded products are clearly defined under the Harmonized Commodity Description and Coding System or HS code, there also exist product codes which are used to collect different types of products which do fit the existing classification. For example, in the 2009 harmonized tariff schedule 12,581 out of 28,985 product categories include a catch-all "other" sub-category. In a combined analysis of multiple product sub-categories, the product categories can generate an indeterminate amount of statistical noise in estimation of price filters.

5. **Quantity faking:** Applications of price filter analysis across multiple commodities often do not take into account the potential misinvoicing of quantities instead of prices, i.e. under or over reporting of trade quantities. Since price filter analysis relies on unit prices of transactions, an over or under-reporting of quantities will also bias the estimates of trade mispricing.

6. **Large quantity transactions with small price differences:** Large quantity transactions where declared prices differ from arm's length prices only by a small margin are harder to detect since the declared unit prices may still fall within the arm's length price range, although the total mispriced amount could be substantial.

7. **Time lag between business transaction and Customs records:** Price filter analysis is based on transaction-level trade data either at the point of export or import. However, the sales transaction between the exporting and importing parties is expected to have taken place at an earlier date than the custom's record. As a result, a comparison of trade values with contemporaneous free-market prices may not be precise. This limitation may be especially relevant for products with volatile prices.

In our application of the price filter analysis method, we introduce some methodological innovations to address these limitations. Firstly, we use qualitative research and expert interviews on commodity characteristics and supply chains to inform our assumptions regarding the selection of price filters around the free-market prices. The main factors we discuss are product heterogeneity, market conditions and contract terms, and shipping costs. Next, we also conduct and report the results from sensitivity analysis based on either setting tighter or looser price filters around the free-market prices. Finally, we also report the results from an alternative method, which uses a 30-day moving average of the free-market prices to account for the time-lag between the dates when the business transaction is completed and when the import is recorded by Swiss Customs.

4. Data Sources

4.1. Swiss Imports Data: 2011-17

The main data source for the transaction-level import statistics with daily frequency is the Swiss Federal Customs Administration for the period of analysis 2011-17. Disaggregated data on gold imports by trading partner is only available from 2012 onward, since this information was kept confidential until 2011 due to political economy and business reasons.[13] The selected commodities and their corresponding HS codes, as per Swiss Federal Customs Administration tariff guidelines, are as follows:[14]

- Non-monetary Gold: HS code: 7108.12 (unwrought gold)
- Refined Copper and Alloys: HS codes: 7403.11 (cathodes), 7403.12 (wire-bars), 7403.13 (billets)
- Cocoa Beans: HS code: 1801.00 (whole or broken, raw or roasted beans)
- Unroasted Coffee Beans: HS code: 901.11 (non-decaffeinated) and 901.12 (decaffeinated)

The summary statistics for the selected commodities are presented in Appendix Table A1. Aggregate annual data for Swiss imports and rest of the world's exports to Switzerland is also accessed via the

[13] According to media reports, the arguments used to justify this decision include keeping commercial sensitive information confidential to assisting the Zurich-based commodity exchanges compete against London commodity exchanges, as well as to conceal politically sensitive information about trade relations with apartheid-era South Africa and the Soviet Union. See: https://www.swissinfo.ch/eng/business/international-trade_counting-gold-in-switzerland/41417986 (accessed: September, 2018)

[14] Swiss Federal Customs Administration List of Tariff Headings document available here: https://www.ezv.admin.ch/ezv/en/home/information-companies/customs-tariff---tares.html (accessed: February, 2018)

United Nations Comtrade database for the corresponding time period. Figures 1-4 report monthly import values of selected commodities using Swiss Federal Customs Administration data.

4.2. Free market commodity price data: 2011-17

We accessed daily-frequency commodity market data from the global financial and macroeconomic database Datastream by Thomson Reuters. The specific commodity exchanges providing this data are listed as follows:

- Gold: London Bullion Market Association (LBMA) - Gold Bullion LBM ($/t oz)
- Copper: London Metals Exchange - LME-Copper, Grade A 3 Months (U$/MT)
- Cocoa Beans: The International Cocoa Organization (ICCO) - Cocoa-ICCO Daily Price (US$/MT)
- Coffee: International Coffee Organization - Coffee-ICO Composite Daily ICA (c/lb)

5. Abnormal Pricing Estimates

In this section, we present the annual estimates of trade mispricing for the selected commodities based on the three different methods, including: free market price filter, interquartile price range filter and partner-country trade gaps. The price filter analysis is based on transaction-level data from Swiss Federal Customs Administration, while the partner-country trade gap analysis uses annual data from the UN Comtrade database.

There are some important distinctions in the interpretation of the estimates from each method which should be carefully considered. Firstly, price filter analysis provides the estimated magnitudes of abnormal pricing, i.e. value of product imports which exceeds the assumed arm's length price range. By comparison, the partner-country trade gaps reveal the aggregate asymmetries or gaps between the import value reported by Switzerland and the total export value reported by the rest of the word, i.e. all the trading partners. These gaps have also been interpreted in the literature as evidence of trade mispricing by developing country exporters, as discussed in Section 2. However, these estimates are not directly comparable. We calculate estimates from both methods in order to facilitate direct comparison of two different measurement techniques and highlight any statistical issues emerging from the comparison of trade data from different sources and at different levels of aggregation.

Next, the price filter analysis results are based on administrative data from a single country, i.e. Switzerland. Therefore, these estimates help us address the limitations associated with comparing mirror statistics.

5.1. Unwrought Gold (HS Code: 7108.12)

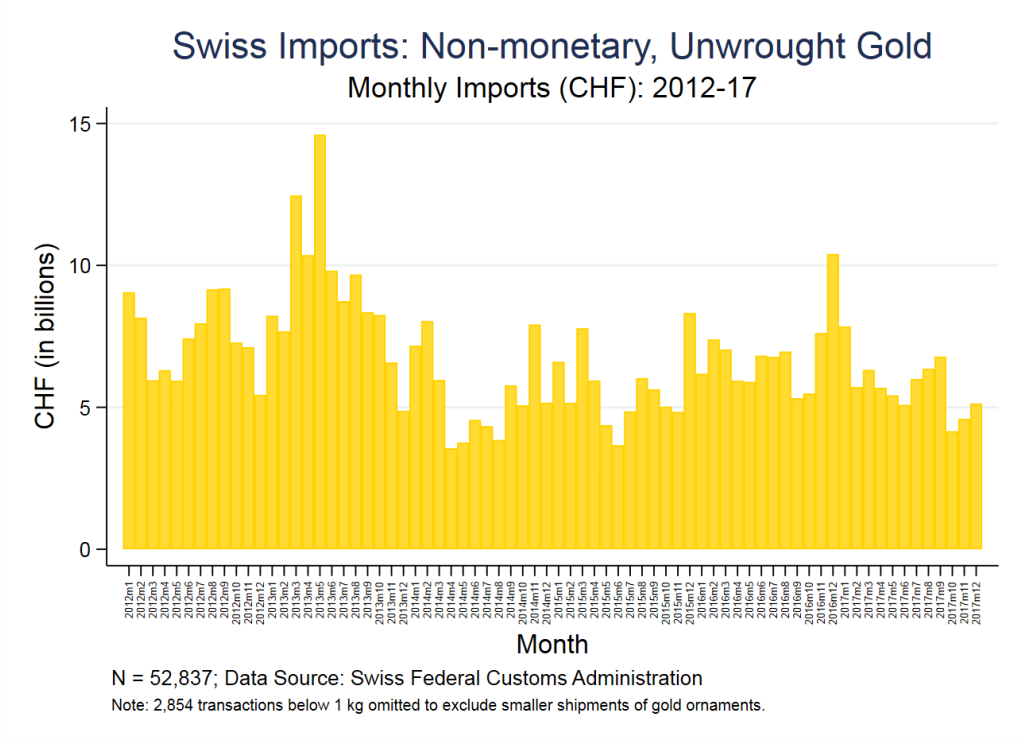
Swiss Customs data indicates that between 2012-17, the country imported on average CHF 80.48 billion of non-monetary, unwrought gold annually (corresponding to tariff classification or HS code: 7108.12).[15] Switzerland imports unwrought gold from 133 countries including gold producers (United States, Peru, China, Thailand, Uzbekistan, Russia, etc.), as well as, trading and shipping hubs (United Kingdom, France, Germany, Belgium, Italy). Unwrought gold imports predominantly comprise of *rough* gold or gold doré bars produced by mining companies or intermediate traders from the extracted gold ore. Doré bars are typically around 80-85% gold, with the balance made up of silver, copper, other base and platinum group metals, and impurities. Unwrought gold is then traded by middlemen or directly transported by the mining companies to precious metals refineries to be purified up to either 99.5% or 99.99% refined gold bars or other semi-manufactured forms for use as investment assets, jewelry fabrication, or industrial and technological uses.[16] As discussed in Section 2, this Customs classification may also include alloys of other precious metals with a minimum of 2% of gold mixed with silver or platinum and other base metals. However, we are unable to account for the share of these transactions due to the data limitation. We exclude 2,854 transactions (approximately 5% of all transactions) below 1 kilogram by weight to omit small gold ornaments or other non-industrial unwrought gold objects, from our analysis. Figure 1 below plots the monthly import values of unwrought gold.

The free market price used to determine the arm's length price range is the London Bullion Market Association (LBMA)'s daily price series. The magnitude of normal deviations around this benchmark price is based on some assumptions informed by qualitative research. Accordingly, we take into account the following criteria which *a priori* are expected to have either a negative **(-)**, positive **(+)** or mixed **(-/ +)** impact on the observed transaction prices.

[15] We also check the magnitude of gold imports in unprocessed ore or concentrates form, but find the imported magnitude to be negligible – approximately CHF 80,000 in 2017 (corresponding to tariff classification or HS code: 2616.90).

[16] See the report by the Platform for Collaboration on Tax (2017) for a detailed discussion on the gold supply chain and valuation.

Figure 1: Swiss Imports – Unwrought Gold (Monthly, 2012-17)



- **Purity and refining costs of unwrought gold (-):** The London Bullion Market benchmark price of gold relates to the proportion of pure gold contained in the traded bars; however doré bars which is the dominant product exported from usually contains 80-85% gold, along with other metals, including silver or copper, and impurities. For some mines, the proportion of pure gold can also be as low as 70%, but this does not imply a proportional reduction in price of the doré bar since the remaining content is usually silver or copper which can is also extracted and utilized.[17] Precious metal refineries charge variable refining costs based on the content of extracted gold and other metals from the doré. These refining, as well as assaying, storage and transportation costs may vary but is expected to be a minor fraction of the value of refined gold. Therefore, the unwrought gold transaction prices are expected to be lower than the benchmark unit prices. For our baseline estimates, we assume a conservative margin of 30% below the market price for pure gold to account for these differences in purity of unwrought gold, presence of other metals in the unwrought form, and associated refining costs.

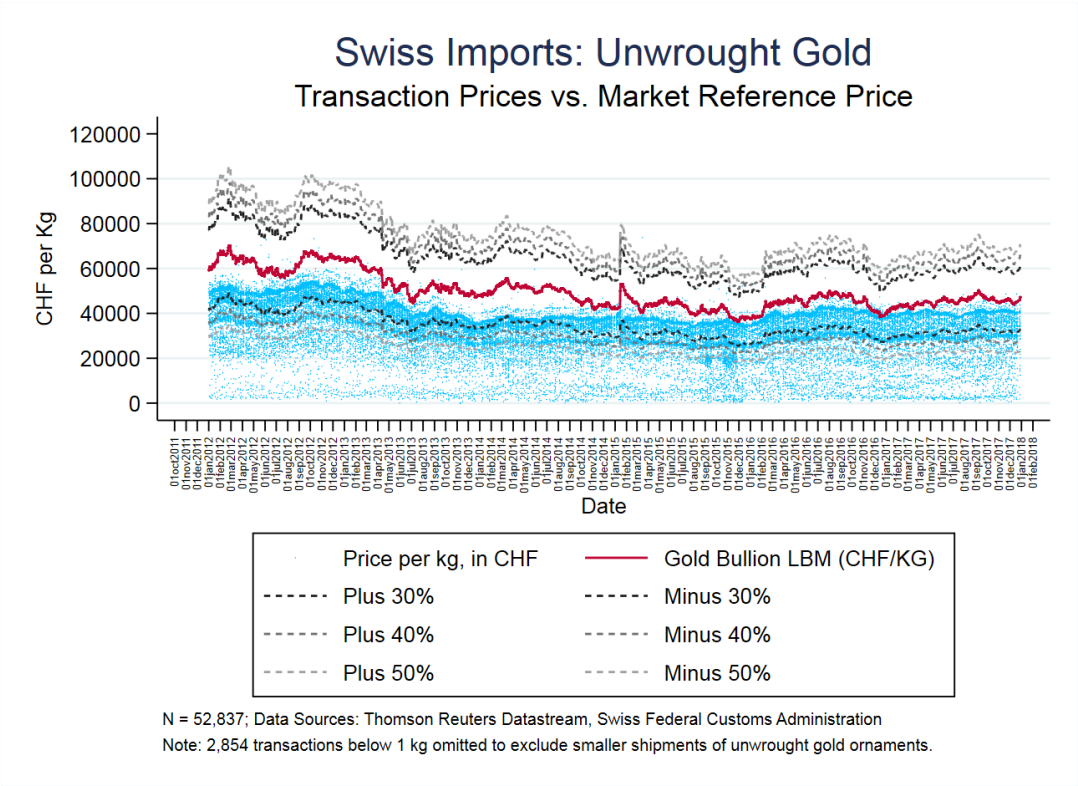
[17] In some cases, the proportion of silver can be much higher than gold, however then it should be recorded under a different product code in Customs statistics (HS code: 7106.91 for unwrought silver) and therefore, should not be included in our data.

- **Market conditions and Contract terms (+ / -):** A limited degree of variation in transaction prices can occurs due to local market conditions and contract terms between transacting parties. For example, gold ore extraction, processing, storage, and insurance costs can vary significantly by source country. Furthermore, large-scale mining companies often have advance pricing agreements with local governments as well as higher investment and operating costs, compared to small-medium scale and artisanal miners. As a result, we expect to see some variation in observed transaction values which may drive the import transaction prices in either direction compared to the benchmark price. For our baseline estimates, we adopt a conservative assumption of 10% variation around the LBMA price series.
- **Transport and insurance costs (+):** Finally, import values are recorded as product cost, plus insurance and freight costs (C.I.F.). The standard assumption in the trade economics literature is to assume that these costs equal 10% of recorded import values. However, since gold is highly valuable precious metal, the transportation and insurance costs constitute a lower proportion of the final value. Therefore, accounting for these costs is expected to have a relatively minor positive impact on the observed import transaction values.[18]

Based on these factors, we conservatively assume an arm's length price range of free market prices plus and minus 40% for our baseline estimates. In Appendix B, we will also report the estimates based on sensitivity analysis assuming different levels of price filters of 30% and 50% around the benchmark prices. By using these clearly highlighted criteria, we aim to address concerns regarding product heterogeneity in the application of price filter analysis. In addition, we will also compare the transaction values versus a 30-day moving average of the commodity exchange price to account for potential time-lag between the date when the transaction is finalized and the import is recorded at a Swiss customs point. Figure 2 reports a scatter-plot of the transaction prices in CHF per kilogram compared to the daily benchmark price series and selected free market price filters for unwrought gold. The estimates for undervalued imports are reported in Table 1 and the corresponding estimates for overvalued imports are in Table 2.

[18] According to an example in Cadot and Conde (2013), the transportation and insurance costs for a trans-continental shipment of gold between major markets corresponded to approximately 2% of the contemporaneous market price.

Figure 2: Unwrought Gold – Transaction-level Prices versus Free Market Prices



N = 52,837; Data Sources: Thomson Reuters Datastream, Swiss Federal Customs Administration
Note: 2,854 transactions below 1 kg omitted to exclude smaller shipments of unwrought gold ornaments.

Based on the above assumptions, the results from free-market price filter analysis indicate that a significant proportion of Swiss gold imports are abnormally under-valued. During 2012-17, the estimated magnitude of undervalued imports equals CHF 82.2 billion, which equals approximately 17% of the total value of imports during this period. By comparison, the magnitude of overvalued imports is negligible (CHF 4.7 million). We discuss various factors which could be driving this large magnitude of under-valued gold imports in Section 5.1. Most prominently, we discuss the implications of significant product heterogeneity in terms of differences in gold production costs and purity based on source, as well as concerns regarding the bargaining power of artisanal and small-scale gold mining companies and traders in negotiating transaction prices using the benchmark, free-market prices. Furthermore, we also discuss the potential impacts of gold derivatives trading in the spot and futures markets in London and New York in driving the benchmark prices, rather than the physical demand and supply of gold. As a sensitivity test, we also report the abnormal pricing estimates based on different levels of assumed deviations in Tables B.1 and B.2 in the appendix. As expected, the results show that estimates of abnormal pricing are sensitive to our assumptions.

The abnormal pricing estimates from the interquartile price range filter are also presented in Tables 1 and 2. The magnitude of abnormally under-valued unwrought gold imports is significantly lower that the free-market price filter estimate, equaling CHF 7.7 billion. This indicates that unwrought gold exports do not significantly deviate from the interquartile range at the exporter-year level. The estimates of abnormally over-valued imports for period 2012-17 are however significantly higher than the free market price filter estimates. This can be explained by the fact that the arm's length price range is now calculated endogenously using observed prices; therefore this method identifies a fixed proportion of under and over-valued transactions by design. Overall, since there is an internationally used market benchmark price for gold, we prefer the estimates generated by the free-market price filter based on the above discussed assumptions.

Finally, we also consider the asymmetries or trade gaps between unwrought gold imports recorded by Switzerland and exports to Switzerland recorded by the rest of the world. By design, this method can only generate either positive, i.e. reported Swiss annual import value exceeds reported exports to Switzerland by trading partners (interpreted as capital inflows to Switzerland via underpriced exports from trading partners) or negative estimates, i.e. reported Swiss annual import value is lower than exports to Switzerland reported by trading partners (interpreted as capital outflows from Switzerland via overvalued exports from trading partners). The results indicate significant, positive trade gaps equaling CHF 218.03 billion in the period 2012-17. On face value, these gaps are indicative of under-invoicing by exporters and illicit inflows of financial capital into Switzerland, which is also consistent with the significant estimates of abnormally under-valued imports generated by free-market price filter analysis.

However, as discussed in Section 3, a wide range of research has demonstrated the significant limitations in this methodology and underlying aggregate trade data. We can rule out the possibility of any significant reporting errors in Swiss statistics from UN Comtrade by finding that the figures match Swiss Federal Customs Administration statistics. See Table C.1 in the appendix for a comparison between Swiss trade data from both sources.[19]

[19] Some minor differences are observed in the trade values of Swiss Customs and UN Comtrade data. These can be explained by different data reporting practices, particularly differences in foreign exchange rates used.

Table 1: Undervalued Imports – Unwrought Gold

Year	Import Value (CHF, million)	Free Market Price Filter: Minus 40% (CHF, million)	Interquartile Range Filter: Below 25th pctle. (CHF, million)	Partner-country Method: Swiss Imports - 1.1*RoW Exports (CHF, million)
2012	88,971	14,292	1,959	-
2013	109,612	13,081	1,510	-
2014	65,151	11,918	881	-
2015	68,220	14,495	674	-
2016	81,805	14,423	1,424	-
2017	69,096	14,001	1,289	-
Mean	**80,476**	**13,701**	**1,290**	-
Total	**482,857**	**82,210**	**7,738**	-

Data Source: Swiss Customs Administration; United Nations COMTRADE

Notes: Product category includes unwrought gold (HS: 7108.12) imports for period 2012-17. Switzerland does not report gold trade data till 2011. Since this customs classification may also record unwrought gold ornaments and other gold products transported in smaller quantities, we exclude transactions below 1 kilogram by weight (N=2,854). The objective is to focus on larger transactions of gold doré. **Free market price** is the daily Gold Bullion price from London Bullion Market (US$ per troy ounce, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table 2: Overvalued Imports – Unwrought Gold

Year	Import Value (CHF, million)	Free Market Price Filter: Plus 40% (CHF, million)	Interquartile Range Filter: Above 75th pctle. (CHF, million)	Partner-country Method: Swiss Imports - 1.1*RoW Exports (CHF, million)
2012	88,971	0.00	2,951	22,206
2013	109,612	0.00	3,489	65,964
2014	65,151	0.00	598	25,222
2015	68,220	3.95	1,167	32,212
2016	81,805	0.00	975	34,550
2017	69,096	0.00	738	37,879
Mean	**80,476**	**0.66**	**1,653**	**36,339**
Total	**482,857**	**3.95**	**9,920**	**218,033**

Data Source: Swiss Customs Administration; United Nations COMTRADE

Notes: Product category includes unwrought gold (HS: 7108.12) imports for period 2012-17. Switzerland does not report gold trade data till 2011. Since this customs classification may also record unwrought gold ornaments and other gold products usually shipped in small quantities, we exclude transactions below 1 kilogram by weight (N=2,854). The objective is to focus on larger transactions of gold doré. **Free market price** is the daily Gold Bullion price from London Bullion Market (US$ per troy ounce, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

5.2. Refined Copper Cathodes (HS code: 7403.11)

Next, we analyze Swiss imports of refined copper cathodes for period 2011-17. Mining companies extract copper ore and process it to obtain 99.9% pure copper cathodes, which are sold primarily to fabricators of semi-manufactured products demanded by final consumers. Copper cathodes are produced and traded under several grades, with lower grades used for low conductivity appliances and alloys. London Metal Exchange (LME) registered copper refineries can manufacture LME registered High (A) Grade cathodes, while Non-LME registered High (A) grade cathodes, Standard Grade cathodes and off-grade cathodes are also produced and traded.

The Swiss trade statistics for refined copper immediately show an unusual pattern: while recorded Swiss imports are very minor (equal to CHF 4.2 million per year on average between 2011-17), the recorded exports of refined copper by the rest of the world to Switzerland is more than 500 times larger (equal to CHF 2.3 billion per year on average between 2011-17). As a result, the observed trade gaps in aggregate data are systematically negative. We hypothesize that this is an example of a "*Switzerland effect*" in international commodity trading statistics, which is driven by merchanting or transit trade operations of Swiss trading firms.[20] In effect, the copper is being reported as sold to Switzerland by the exporter however, the product is physically stored and re-sold to a buyer in a third country. As a result, we expect this effect to distort the international trade statistics of refined copper cathodes. As Figure 3 reports below, physical imports of refined copper cathodes are low.

For completeness, we also conduct price filter analysis to detect abnormal pricing for minor amounts of copper imports recorded by Swiss Customs. The free market price used to determine the arm's length price range is the 'LME-Copper, Grade A' price-series from LME. The choice of price filter around this benchmark price is based on the following assumptions informed by qualitative research:

- **Product heterogeneity (-):** The London Metal Exchange benchmark prices for refined copper relate to Grade A copper cathode, while there are many different grades of copper traded internationally which differ in purity and in the types of "impurity" elements contained. Therefore, the refined copper import transaction prices are expected to vary from the benchmark prices for Grade A copper cathodes. For our baseline estimates, we assume that product heterogeneity can result in variations of 10% below the benchmark prices.

[20] Prominent Swiss trading firms involved in trading refined copper include: 1) Trafigura: https://www.trafigura.com/our-services/metals-minerals/refined-metals/ ; 2) Glencore: http://www.glencore.com/what-we-do/metals-and-minerals

- **Market conditions and Contract Terms (+ / -):** Same as for other commodities, we anticipate some level of normal variation in transaction prices due to business conditions, including contract terms, product characteristics, and transacting partners. Copper ore extraction, smelting, storage, and insurance costs can vary significantly by source. As a result, we expect to see some normal variation in observed transaction values which may drive the import transaction prices in either direction compared to the benchmark, free-market prices. We assume 10% variation around the free-market price series due to normal business conditions.

- **Transport and insurance costs (+):** Finally, import prices are recorded as product cost, plus insurance and freight costs. Refined copper cathode is a relatively valuable product that is traded in large quantities. We assume that transportation and insurance costs comprise less than 5% of the final value of shipments and accounting for these costs is expected to have a minor positive impact on the observed import transaction values.

Figure 3: Swiss Imports – Refined Copper (Monthly, 2011-17)

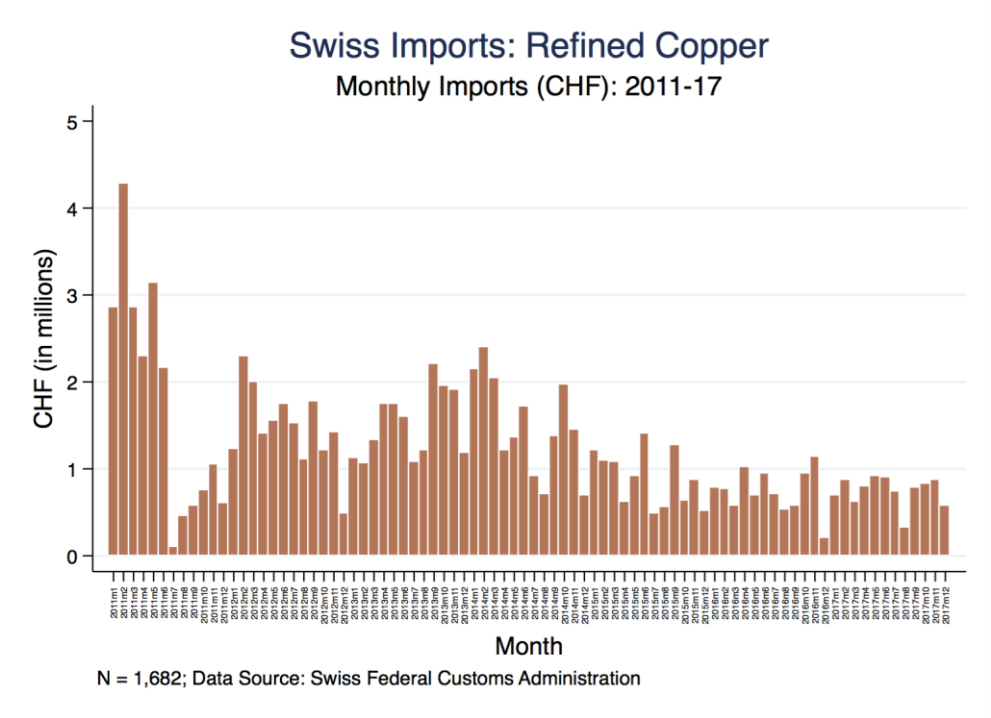


Figure 4: Refined Copper – Transaction-level Prices versus Free Market Prices

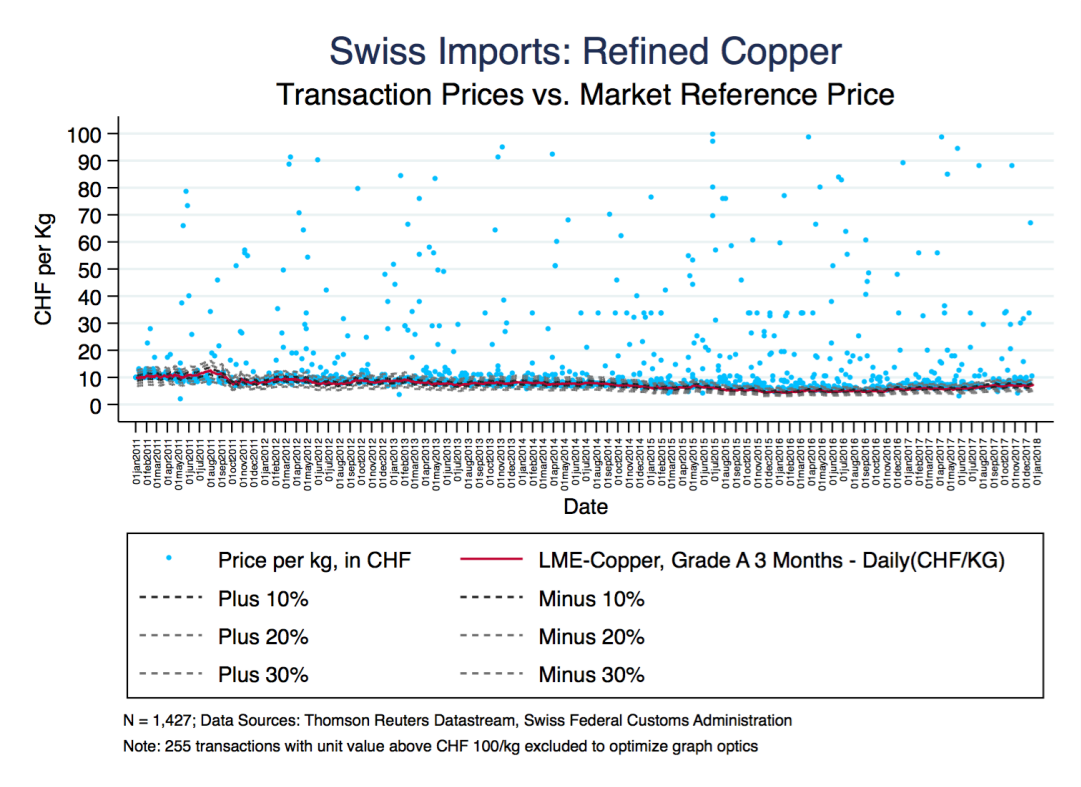


Table 3: Undervalued Imports: Refined Copper

Year	Import Value (CHF, million)	Free Market Price Filter: Minus 20% (CHF, million)	Interquartile Range Filter: Below 25th pctle. (CHF, million)	Partner-country Method: Swiss Imports – 1.1*RoW Exports (CHF, million)
2011	4.62	0.42	0.37	- 3,725
2012	4.89	0.00	0.15	- 3,583
2013	6.39	0.00	0.13	- 3,669
2014	5.76	0.03	0.06	- 3,876
2015	2.30	0.00	0.06	- 2,590
2016	2.55	-	0.05	- 299
2017	3.34	0.00	0.04	- 256
Mean	**4.26**	**0.07**	**0.12**	**- 2,571**
Total	**29.84**	**0.46**	**0.86**	**- 18,003**

Data Source: Swiss Customs Administration; United Nations COMTRADE
Notes: Product categories include refined copper cathodes and sections of cathodes (HS: 7403.11) for period 2011-17. **Free market price** is the daily LME-Copper, Grade A price from London Metals Exchange (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated on annual basis for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table 4: Overvalued Imports - Refined Copper

Year	Import Value (CHF, million)	Free Market Price Filter: Plus 20% (CHF, million)	Interquartile Range Filter: Above 75th pctle. (CHF, million)	Partner-country Method: Swiss Imports - 1.1*RoW Exports (CHF, million)
2011	4.62	0.12	0.05	-
2012	4.89	0.20	0.12	-
2013	6.39	0.21	0.05	-
2014	5.76	0.05	0.05	-
2015	2.30	0.05	0.03	-
2016	2.55	0.09	0.04	-
2017	3.34	0.13	0.11	-
Mean	**4.26**	**0.12**	**0.07**	-
Total	**29.84**	**0.86**	**0.52**	-

Data Source: Swiss Customs Administration; United Nations COMTRADE
Notes: Product categories include refined copper cathodes and sections of cathodes (HS: 7403.11) for period 2011-17. **Free market price** is the daily LME-Copper, Grade A price from London Metals Exchange (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated on annual basis for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

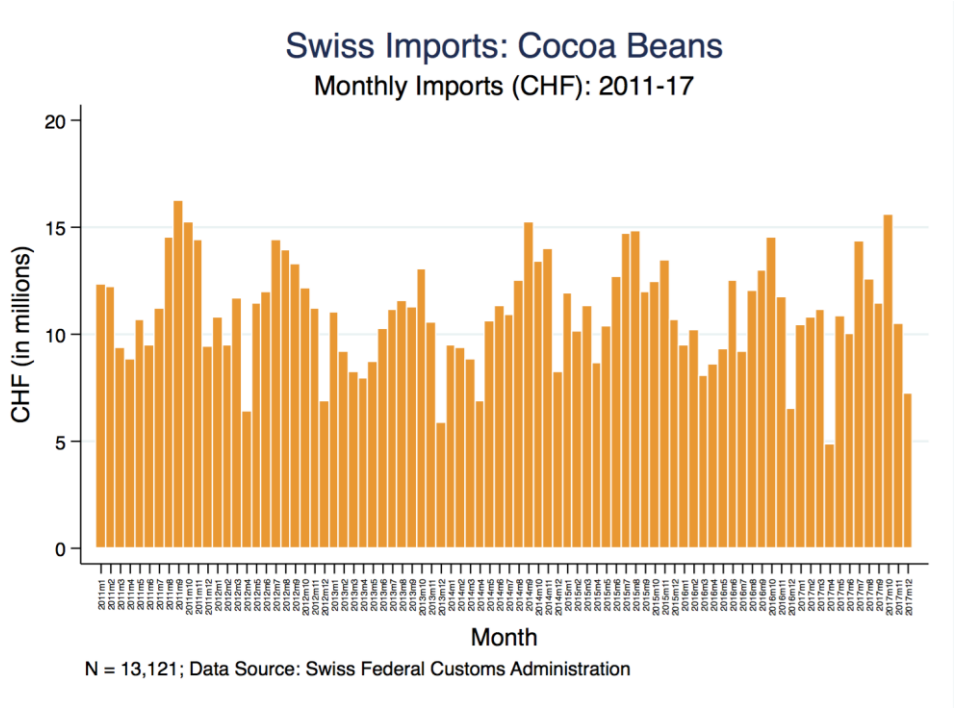
To account for the above factors, we conservatively assume an arm's length price range of 20% around the free market price for refined copper. In the appendix, we will also report the estimates based on sensitivity analysis assuming different levels of price filters, including 10% and 30% price filters. In addition, we will also compare transaction values versus a 30-day moving average of the benchmark, free-market prices to account for an assumed time-lag between the transaction completion and importation dates. Figure 4 reports a scatter-plot of the refined copper cathode import prices in CHF per kilogram compared to the daily benchmark price series and selected free market price filters for unwrought gold. The estimates for undervalued imports are reported in Table 3 and overvalued imports in Table 4.

The results from both free market and interquartile price filter analysis indicate very small estimates of either under or overvalued imports. However, as discussed earlier the partner country trade gaps between reported Swiss imports and exports to Switzerland from the rest of the world are significantly larger. In the case of copper, these asymmetries are systematically negative for Switzerland, indicating that Swiss trading partners are reporting significantly higher exports to Switzerland than the recorded imports of Switzerland. While trade mispricing and customs fraud can not be ruled out in all cases, we hypothesize that that significantly large magnitude of these trade gaps is driven by merchanting operations of Swiss trading firms.

5.3. Cocoa Beans (HS Code: 1801.00)

Next we analyze cocoa beans, which is an important agricultural commodity for Swiss trading and consumer food production companies. Figure 5 reports the month import values of cocoa beans below. The traded cocoa beans are produced after fermentation and drying of the raw beans and is used in the manufacturing of processed foods, including chocolate and cocoa powder. The two dominant sources of cocoa beans traded internationally include Ivory Coast and Ghana, however Switzerland also imports significant amounts of cocoa from Ecuador, Madagascar, and Peru. In addition, Switzerland also imports cocoa beans from Italy, Belgium, Germany, and Netherlands but these are trading and shipping hubs for the product. Finally, we confirm that Switzerland is a major consumer of cocoa beans by checking that imports far exceed exports of cocoa beans, which are very minor in value (CHF 1.5 million exported by Switzerland in 2016, compared to CHF 128 million in imports).

Figure 5: Swiss Imports – Cocoa Beans (Monthly, 2012-17)



We now analyze the transaction-level import data to determine the magnitude of abnormal pricing. As discussed in Section 1, we prefer the estimates based on interquartile price range calculated at the exporter-year level for cocoa beans. However, we also report the results from free-market price filter analysis based on 'Cocoa-ICCO Daily Price' recorded by the International Cocoa Organization (ICCO). Our qualitative research however indicates that it has significant limitations as a uniformly

reliable benchmark due to the significant differences in types and quality of cocoa beans traded internationally.

Figure 6 reports the daily benchmark price and selected free market price filters for cocoa beans using commodity exchange data accessed via Thompson Reuters Datastream database. The assumption of the price filter around the ICCO daily price series is informed by the following qualitative research criteria:

- **Product heterogeneity (+ / -):** Firstly, the ICCO daily price series is an average across the prices for cocoa beans from different regions. While Customs data does not record the type of cocoa beans being imported, we know that the two dominant sources of cocoa beans traded internationally include Ivory Coast and Ghana. ICCO price data reveals that Ivory Coast cocoa prices exceeded ICCO average prices by 11% on average (standard deviation of 4%), while Ghana cocoa prices exceeded the average by 14% on average between 2011-17 (standard deviation of 4%). Other important cocoa producing regions include Latin American and South-east Asia where prices are lower compared to the premium varieties from West Africa. For our baseline estimates, we assume that cocoa bean heterogeneity contributes to 10% variation around the free-market price due to normal business conditions.

- **Market conditions and Contract Terms (+ / -):** Similar to extractive commodities, we anticipate some level of normal variation in cocoa bean transaction prices due to business conditions. Raw cocoa beans are processed and stored for significant periods of time before being sold to final consumers, and associated costs can vary significantly by source. As a result, we expect to see some normal variation in observed transaction values which may drive the import transaction prices in either direction compared to the benchmark, free-market prices. For our baseline estimates, we adopt a conservative assumption of 10% variation around the free-market price due to normal business conditions.

- **Transport and insurance costs (+):** Finally, we assume that transportation and insurance costs for cocoa beans accounts for 10% of their recorded import valuation. Accounting for these costs is expected to have a positive impact on the observed import transaction values.

Based on these factors, we assume an arm's length price range of 30% around the free market price.

In the appendix, we will also report the estimates based on sensitivity analysis assuming different levels of price filters, including 20% and 40% around the benchmark ICCO price series. In addition,

we will also compare the transaction values versus a 30-day moving average of the benchmark, free-market prices to account for time-lag between the transaction completion and import dates.

Figure 6: Cocoa Beans – Transaction-level Prices versus Free Market Prices

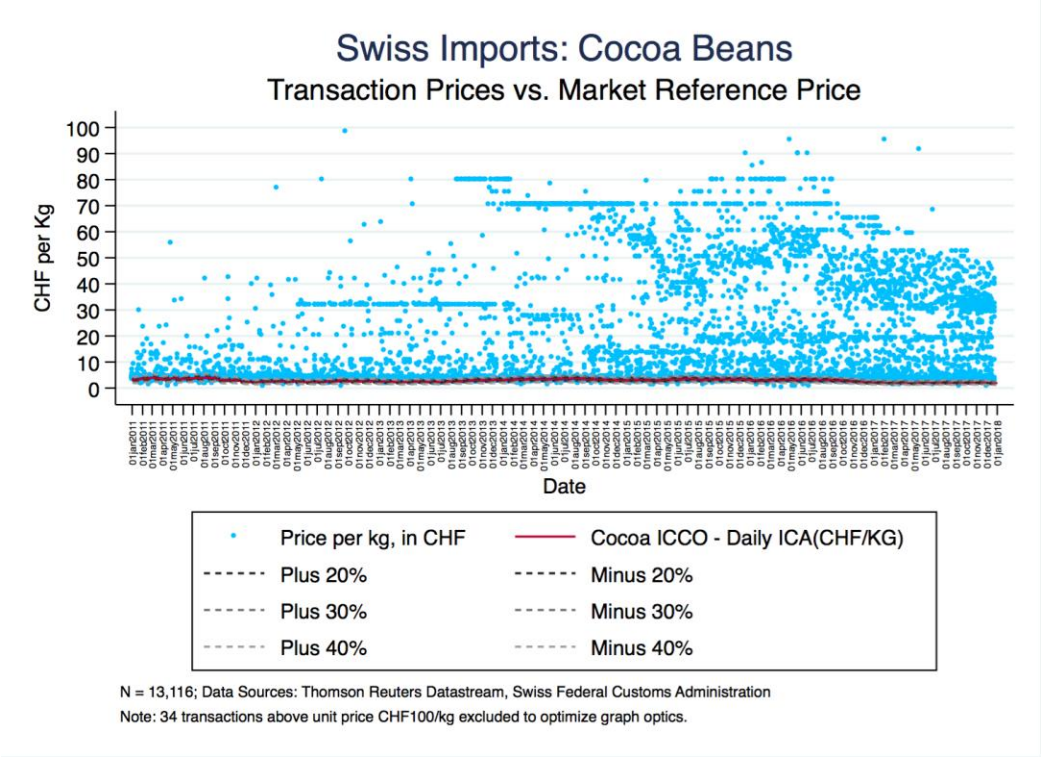


Figure 6 reports a scatter-plot of import prices in CHF per kilogram compared to the daily benchmark price series and selected free market price filters for cocoa beans. The estimates for under and over-valued imports are reported in Tables 5 and 6 respectively. Our findings are as follows: we find minor magnitudes of abnormally under-valued imports, equal to CHF 44.7 million for cocoa beans (5% of total import value) between 2011-17. As discussed in section 1, these estimates should be interpreted as the upper limit of abnormally under-valued imports to Switzerland. Therefore, we conclude that the phenomenon of abnormally under-valued imports is relatively minor, but not insignificant in agricultural commodities. We also observe comparatively small magnitudes of over-valued cocoa bean imports to Switzerland, equal to 1% of imports for cocoa between 2011-17.

Table 5: Undervalued Imports - Cocoa Beans

Year	Import Value (CHF, million)	Free Market Price Filter: Minus 30% (CHF, million)	Interquartile Range Filter: Below 25th pctle. (CHF, million)	Partner-country Method: Swiss Imports - 1.1*RoW Exports (CHF, million)
2011	143.79	0.23	2.66	-
2012	133.49	0.01	4.82	-
2013	118.67	0.00	2.01	-
2014	130.69	0.02	1.70	-
2015	143.13	0.00	7.07	-
2016	125.06	0.00	18.37	-
2017	129.76	0.01	8.07	-
Mean	**132.08**	**0.04**	**6.39**	-
Total	**924.59**	**0.29**	**44.71**	-

Data Source: Swiss Customs Administration; United Nations COMTRADE
Notes: Product category includes cocoa beans (HS: 1801.00) for period 2011-17. **Free market price** is the Cocoa-ICCO Daily Price (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated at the exporter-year level for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table 6: Overvalued Imports - Cocoa Beans

Year	Import Value (CHF, million)	Free Market Price Filter: Plus 30% (CHF, million)	Interquartile Range Filter: Above 75th pctle. (CHF, million)	Partner-country Method: Swiss Imports - 1.1*RoW Exports (CHF, million)
2011	143.79	2.91	2.13	115.71
2012	133.49	8.18	1.95	93.74
2013	118.67	3.73	1.80	95.85
2014	130.69	0.73	2.02	105.50
2015	143.13	1.68	2.77	121.45
2016	125.06	3.73	2.48	108.60
2017	129.76	16.23	2.39	125.53
Mean	**132.08**	**5.31**	**2.22**	**109.48**
Total	**924.59**	**37.18**	**15.55**	**766.38**

Data Source: Swiss Customs Administration; United Nations COMTRADE
Notes: Product category includes cocoa beans (HS: 1801.00) for period 2011-17. **Free market price** is the Cocoa-ICCO Daily Price (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated at the exporter-year level for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

The free-market price filter analysis estimates of abnormally under-valued imports are also relatively minor, equaling less than CHF 0.3 million between 2011-17. However, the estimates of abnormally over-valued imports are significantly larger equaling CHF 37 million or 4% of total imports for the period 2011-17. Generally, we observe a significant proportion of transactions are priced above market prices, even after accounting for the premium prices for the high-quality beans from Ghana and Ivory Coast. These observed pricing patterns of cocoa imports can be driven by different product and market related factors, which will need to be evaluated using additional qualitative research. For instance, Swiss consumer food firms may demand the highest quality cocoa beans that are priced at a significant premium compared to the composite ICCO prices. Relatedly, we also observe some indications of fixed pricing arrangements in the data whereby Swiss imports are paying fixed rates for their shipments of cocoa beans, irrespective of contemporaneous free market prices.

Furthermore, the impact of financial derivatives that are used to provide advance liquidity and hedge financial risk by producers and traders of cocoa is also unclear. In order to provide liquidity for their operations, producers like Ghana's Cocoa Marketing Board sell their produce up to a year in advance of final production using future contacts, which are actively traded on commodity exchanges. The spot-future parity condition implies that the spot prices used in the price filter analysis deviates from futures prices based on the extent of risk-free interest rates and carrying costs, including storage, transportation, and insurance. These factors should then be reflected in the observed transaction prices of the physical product. Significant trading in cocoa derivatives also takes place in commodities exchanges but which is not linked to the demand and supply of physical commodity, while still having an impact of the free-market prices.

We also consider the interquartile range price filter estimates that find relatively higher levels of abnormally under-valued imports (CHF 24.21 million or 3% of total imports) and relatively lower levels of abnormally over-valued imports compared to the free-market price filter method. These differences are explained by the observed distribution of transaction prices significantly exceeding the benchmark price series due to which the assumed arm's length price range is now shifted upwards. Overall, these interquartile price range estimates may be useful in studying pricing patterns in this case where transaction prices do not appear to correspond to the commodity exchange prices. However, these estimates remain hard to reliably interpret without further information on product characteristics that is not available in Customs data.

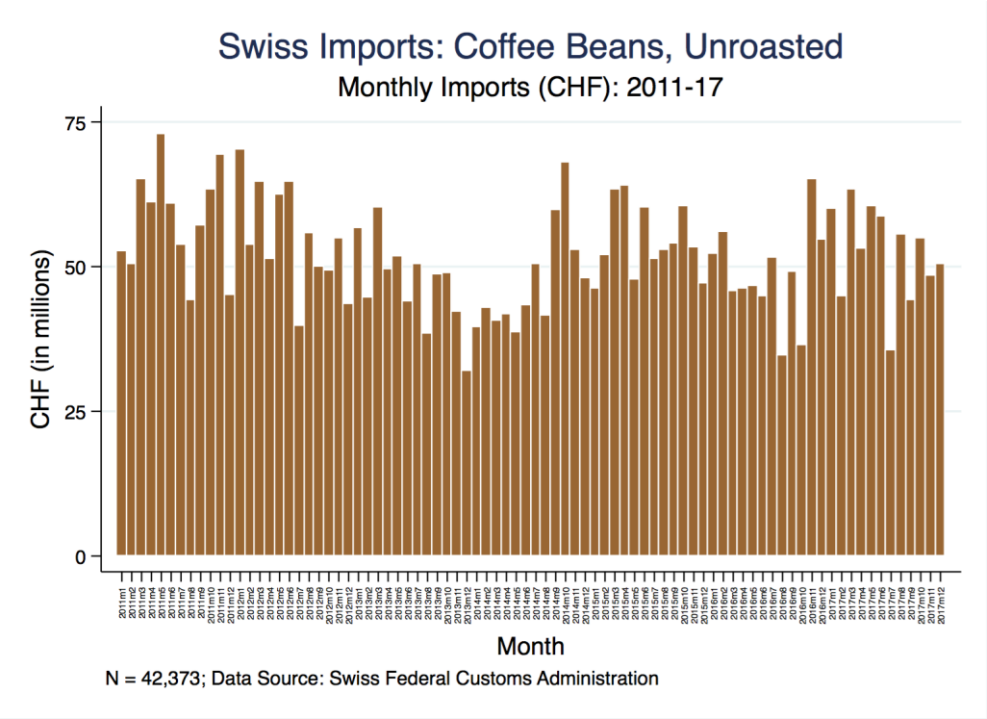
Finally, we observe that the partner country trade gaps are systematically positive and significantly larger than the abnormal pricing estimates based on transaction-level data. This implies that Switzerland is reporting higher import values than those reported by its trading partners. Unlike the case of gold trade, we have already verified that Switzerland is not a processing hub for cocoa beans but is more likely the final consumer given the negligible cocoa exports from Switzerland. As a result, we hypothesize that these large positive asymmetries could be driven due to an entrepôt trade effect whereby exporting countries are recording intermediate shipping or storage hubs as the final destination of their exports. However, these products are finally shipped to Switzerland, which records the original source country as the exporter. The value of final imports into Switzerland may also be distorted since trading firms take advantage of price arbitrage opportunities by storing the cocoa beans in intermediate hubs for up to several years. We also cannot rule out the occurrence of some magnitude of trade mispricing in cocoa imports to Switzerland.

5.4. Un-roasted Coffee Beans (Non-decaffeinated HS Code: 0901.11 and Decaffeinated HS Code: 0901.12)

Finally, we analyze coffee beans as an alternate agricultural product traded and consumed by Swiss trading and consumer food firms. Figure 7 reports the monthly values of coffee imports by Switzerland. There are two main types of coffee beans: Robusta and Arabica, but coffee is a significantly heterogeneous commodity that is differentiated by bean type and natural conditions such as altitude, latitude, and volcanic soil. After harvesting, coffee beans are transported to processing mills for processing, sorting, and grading by size, weight, and form. Processing coffee involves converting the raw fruit of the coffee cherry into the green (dried) coffee beans. International coffee trade mostly involves green coffee (dried berries) packed in 130 pound bags. Coffee roasting is usually completed by the final processing company or at a coffee house after blending coffee beans of different origin and type together.

For our analysis, we will use data on unroasted coffee beans, both non-decaffeinated and decaffeinated (HS: 901.11 and 901.12, respectively) for period 2011-17. Similar as cocoa, we prefer the abnormal pricing estimates based on interquartile range price filters. However, despite its less than universal applicability, we also conduct free market price filter analysis using the 'ICO Daily Price' recorded by the International Coffee Organization (ICO). The qualitative research criteria that inform our assumptions regarding the appropriate price filter are as follows:

Figure 7: Swiss Imports – Coffee Beans (Monthly, 2012-17)



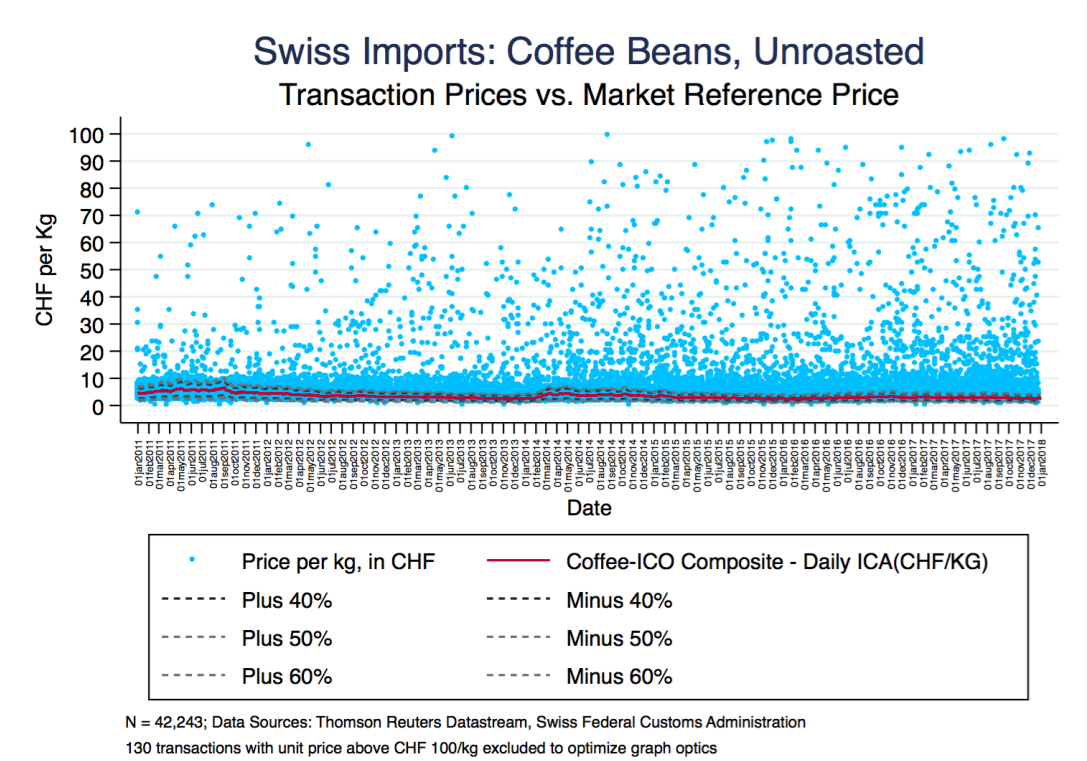
- **Product heterogeneity (+ / -):** Firstly, the ICO daily price series is an index across the prices for different types of coffee beans from different regions. The two main types traded internationally include Arabicas and Robustas. ICO price data reveals that the average Arabica bean prices exceeded ICO benchmark prices by 24% on average (standard deviation of 6%), while average Robusta prices were lower than the ICO benchmark by 31% on average between 2011-17 (standard deviation of 10%). For our baseline estimates, we assume that cocoa bean heterogeneity contributes to 30% variation around the free-market price due to normal business conditions.

- **Normal variation due to business conditions (+ / -):** Similar to extractive commodities, we anticipate some level of normal variation in coffee bean transaction prices due to business conditions. Raw coffee beans are processed and stored for significant periods of time before being sold to final consumers, and associated costs can vary significantly by source. As a result, we expect to see some normal variation in observed transaction values which may drive the import transaction prices in either direction compared to the benchmark, free-

market prices. For our baseline estimates, we adopt a conservative assumption of 10% variation around the free-market price due to normal business conditions.

- **Transport and insurance costs (+):** Finally, we assume that transportation and insurance costs for coffee beans accounts for 10% of their recorded import valuation. Accounting for these costs should have a positive impact on the observed import transaction values.

Figure 8: Coffee Beans – Transaction-level Prices versus Free Market Prices



Based on these factors, we conservatively assume an arm's length price range of 50% around the free market price. In the appendix, we will also report the estimates based on sensitivity analysis assuming different levels of price filters, including 40% and 60%. Finally, we will also compare the transaction values versus a 30-day moving average of the benchmark, free-market prices to account for time-lags between the transaction and import dates. Figure 8 reports a scatter-plot of import prices in CHF per kilogram compared to the daily benchmark price series and selected free market price filters for unroasted coffee. The estimates for undervalued imports are reported in Table 7 and the corresponding estimates for overvalued imports are in Table 8.

Table 7: Undervalued Imports - Coffee Beans, Not Roasted

Year	Import Value (CHF, million)	Free Market Price Filter: Minus 50% (CHF, million)	Interquartile Range Filter: Below 25th pctle. (CHF, million)	Partner-country Method: Swiss Imports - 1.1*RoW Exports (CHF, million)
2011	695.87	7.08	25.81	-
2012	660.38	0.48	15.08	-
2013	567.24	0.03	15.05	-
2014	567.51	1.62	13.87	-
2015	652.25	0.07	21.12	-
2016	582.98	0.06	17.01	-
2017	629.24	0.05	20.90	-
Mean	**622.21**	**1.34**	**18.41**	-
Total	**4,355.47**	**9.40**	**128.85**	-

Data Source: Swiss Customs Administration; United Nations COMTRADE
Notes: Product categories include coffee beans, not roasted, decaffeinated and not-decaffeinated (HS: 901.11 and 901.12) for period 2011-17. **Free market price** is the International Coffee Organization ICO Daily Price (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated at the exporter-year level for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table 8: Overvalued Imports - Coffee Beans, Not Roasted

Year	Import Value (CHF, million)	Free Market Price Filter: Plus 50% (CHF, million)	Interquartile Range Filter: Above 75th pctle. (CHF, million)	Partner-country Method: Swiss Imports - 1.1*RoW Exports (CHF, million)
2011	695.87	12.35	14.93	256.70
2012	660.38	50.30	17.69	326.66
2013	567.24	43.29	11.58	283.00
2014	567.51	13.35	15.36	335.36
2015	652.25	97.00	14.32	412.71
2016	582.98	55.59	17.78	351.49
2017	629.24	59.10	12.46	505.17
Mean	**622.21**	**35.03**	**14.87**	**353.01**
Total	**4,355.47**	**330.98**	**104.12**	**2,471.09**

Data Source: Swiss Customs Administration; United Nations COMTRADE
Notes: Product categories include coffee beans, not roasted, decaffeinated and not-decaffeinated (HS: 901.11 and 901.12) for period 2011-17. **Free market price** is the International Coffee Organization ICO Daily Price (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated at the exporter-year level for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Same as for cocoa, our results show relatively minor magnitudes of abnormally under-valued imports, equal to CHF 128.9 million (3% of total import value) between 2011-17. Furthermore, these estimates should be interpreted as the upper limit of abnormally under-valued imports to Switzerland due to the endogeneity of the interquartile range price filter. Therefore, we conclude that the phenomenon of abnormally under-valued imports is relatively minor, but not insignificant in agricultural commodities. We also observe small magnitudes of over-valued coffee bean imports to Switzerland, equal to 2% of imports for coffee between 2011-17.

The free market price filter analysis estimates for coffee demonstrate a similar pattern of results as for cocoa beans. The magnitude of abnormally under-valued imports is negligible, equaling CHF 9.4 million or 0.002% of total imports between 2011-17. However, the data demonstrates that a significant proportion of imports are abnormally over-valued even after accounting for the deviation due to higher prices for premium Arabica coffee beans. The estimates of overvalued imports based on free market price filters equal CHF 331 for the period 2011-17 (7.6% of total imports between 2011-17). Same as for cocoa, these observed pricing patterns could be driven by different product and market related factors, including a preference for coffee beans, which are priced at a significant premium compared to the composite ICO price series.

Finally, we once again observe that the partner country trade gaps are systematically positive and significantly larger than the abnormal pricing estimates based on transaction-level data. We verify that Switzerland is not a transit hub but is more likely the final consumer given the negligible exports of unroasted coffee beans. As a result, we hypothesize that these large positive asymmetries could be driven due to an *entrepôt trade* effect whereby exporting countries are recording intermediate shipping or storage hubs as the final destination of their exports. However, these products are finally shipped to Switzerland, which records the original source country as the exporter. The value of Swiss import transactions could also be distorted by trading firms storing the beans in intermediate hubs to take advantage of price arbitrage opportunities. Finally, as with the other commodities, trade mispricing and customs fraud are other potential factors driving these asymmetries but it is not possible to reliably estimate their magnitude using aggregate data.

6. Discussion of Main Results

Our analysis for the period 2011-17 reveals the presence of economically significant estimates of abnormal pricing in certain commodities. In addition, we also observe significant asymmetries in the

mirror trade statistics from Switzerland and its trading partners. These annual trade gaps are systematically positive for gold, cocoa, and coffee indicating that reported Swiss imports exceed what the rest of the world reports as exports to Switzerland. However, the gaps are systematically negative for copper indicating the opposite phenomenon. We now discuss some hypotheses to explain these observed results, which will be tested in future research.

6.1. Drivers of Abnormally Under-valued Gold Imports

Gold imports demonstrate the highest magnitudes of abnormal pricing using free-market price filter analysis. After conservatively assuming a 40% price filter to account for the *a priori* negative impact of reduced purity of gold, refining costs, and business conditions on transaction prices, as well as the expected positive impact of the presence of other metals, and transportation, insurance costs, our estimates indicate abnormal under-valuation of CHF 13.7 billion per year on average between 2012-17. Even after expanding the price filter to 50% to provide further flexibility; the estimates remain economically significant equaling CHF 10.4 billion per year on average. Finally, it is also observed that the abnormally under-valued transactions originate from both trading and shipping hubs (Germany, United Kingdom, Spain, and Italy), as well as producer countries (Peru, Argentina, Philippines, Australia, Kazakhstan, among others).

Some factors which could potentially explain the observed magnitude of abnormally under-valued imports are as follows:

Firstly, the gold production costs, which include extraction, processing, storage, transportation and insurance costs can vary significantly by source. By mapping mine-level or country-level costs of producing gold doré to the observed Swiss import values, we can test the hypothesis that lower production costs account for significant deviation of import prices from the free-market prices.

Secondly, it is possible that significant amounts of low-quality unwrought gold containing a much smaller percentage of pure gold (and other valuable metals) compared to other impurities by weight is being imported by Swiss refineries. Expert interviews with traders and refineries can help us better understand whether poor quality imports from particular sources are driving the observed estimates of abnormally under-valued imports.

Thirdly, artisanal and small-scale mining (ASM) companies often do not possess the negotiating power or technical acumen to accurately value their sales to international traders. ASM actors can form a significant proportion of the mining sector in certain developing countries; therefore it would

be useful to test this hypothesis by collecting more information on the characteristics of exporters trading gold with Swiss firms.

Finally, it is not obvious that all gold mining companies and traders selling unwrought gold to Swiss importers use the LBMA gold price series as their benchmark. Gold is one of the most traded assets worldwide with daily turnover in the London gold market approximately equal to the daily trade volume on the all the world's stock exchanges combined (Hauptfleisch, et al. 2016). Furthermore, the LBMA benchmark gold price is derived from a combination of the London OTC and New York Mercantile Exchange Futures Market (COMEX) futures prices, which both trade in derivatives or 'paper gold' which is only fractionally backed by physical gold.[21] As a result, it will be further research is required to test whether LBMA price series is an accurate benchmark for Swiss imports.

6.2. Potential '*Switzerland Effect*' in aggregate trade statistics

Moving on to refined copper, we already discussed the strikingly large asymmetries in reported imports by Swiss customs and exports by trading partners. These magnitudes appear to be too large and systematic to be explained completely by alternative explanations of trade mispricing and data inaccuracies. Accordingly, we hypothesize that a *Swiss merchant trade effect* exists in international trade statistics for copper due the large magnitude of merchanting activities, whereby Swiss trading companies purchase copper cathodes which are accordingly recorded as exports to Switzerland by the producer countries. However, the physical copper shipments do not enter Swiss Customs territory but are re-sold to a third country. This hypothesis is supported by Brulhart, Dihel, & Kukenova (2015) case study on Zambia. In their analysis of Zambia Customs micro-data, they state the following, "*Astonishingly, Switzerland appears as Zambia's main export destination in the most recent sub-period, 2008-2011, absorbing more than half of all Zambian exports. This cannot possibly reflect the true flow of goods. In Swiss import data, reported imports from Zambia are some 6,000 times smaller than reported Zambian exports to Switzerland. Moreover, Swiss import statistics do not suggest copper to feature among Switzerland's main import products from Zambia. Hence, a large part of Zambian mining exports are evidently assigned to Switzerland in the statistics because the relevant multinational firms are headquartered there and not because the goods are destined for or even physically shipped to Switzerland. This is a major flaw in data quality, and it also potentially has considerable revenue implications for the Zambian authorities* (page 4, Brulhart, Dihel, & Kukenova, 2015)"

[21] The two major centers for gold trading are the London over-the-counter (LOTC) spot market and the New York Mercantile Exchange Futures Market (COMEX), account for approximately 78.0% and 7.7% of the total gold turnover, respectively (Hauptfleisch, Putniņš, & Lucey, 2016).

Finally, we observe large positive trade gaps in the case of agricultural commodities including cocoa beans and coffee. In this case, we do not find supporting data in favor of significant merchanting or domestic processing for re-export driving these asymmetries. Furthermore, we note that agricultural commodities are used as inputs for the manufacture of consumer food products which transform the original raw material, including chocolate and roasted, branded coffee. These final products are consumed domestically and also appear as significant exports from Switzerland. As a result, we believe that these asymmetries are driven by a combination of standard factors including entrepôt trade due to the land-locked nature of Switzerland (where agricultural commodities are usually transported by shipping containers and railways due to their bulk). However, we cannot rule out the presence of customs fraud and trade mispricing in the agricultural exports from producer countries which may be driving the large observed asymmetries.

6.3. Demand for high-quality agricultural commodities by Swiss consumer food firms

Using the transaction-level data of commodity prices, we observe that a significant amount of our selected agricultural commodity imports are valued significantly higher than the corresponding free-market benchmark prices. We hypothesize that the abnormally over-valued magnitude of trade could be partly driven by the demand for high-quality inputs which are priced at a significant premium than the corresponding free-market price. The manufacturers of premium consumer food products may be inflexible in their demand for premium agricultural products, which are supplied by large trading firms at a significantly higher price compared to the benchmark prices for raw commodities. One of the alternative explanations includes deliberate over-pricing of exports by exporters in the producer countries which is a channel for outflows of financial capital from Switzerland. However, this explanation is not entirely consistent with the aggregate reported value of exports from Swiss trading partners which are significantly lower than imports recorded in Switzerland.

7. Conclusion and Further Research

Illicit financial flows (IFFs) through commodity trade mispricing are argued to pose a significant development challenge for resource-rich, developing countries by eroding their tax base. Two overlapping channels have been identified by researchers, including trade misinvoicing and abusive transfer pricing. This paper aims to contribute new evidence to the IFF literature by estimating the

magnitude of abnormal pricing, i.e. magnitude of trade valued outside arm's length range, for Swiss commodity imports from the rest of the world. This analysis is based on price-filter analysis whereby transaction-level prices are compared to free market prices from commodity exchanges or trading bodies, as well as with endogenously calculated interquartile price range. We also compare these abnormal pricing estimates with the more commonly used asymmetries observed in aggregate, product-level data. Switzerland provides an interesting case study for analyzing abnormal pricing in commodity trade given its status as a trading hub, however it also poses some challenges given the heterogeneity in potential partner-country characteristics driving abnormal pricing.

In further research, we will analyze the potential impact of these source-country characteristics, including commodity characteristics, as well as economic and regulatory drivers in future work (Marur, 2019). In conclusion, we once again note that the abnormal pricing estimates based on price-filter analysis should be interpreted as indicative rather than causal evidence of trade and transfer mispricing. Specific cases of abusive transfer pricing or customs fraud may only be determined on the basis of using such suggestive evidence to identify and conduct an audit of the pricing practices of specific actors engaged in abnormally priced commodity trade. We propose and will conduct further research on the different hypotheses which may explain the observed magnitudes of abnormal pricing and asymmetries in aggregate mirror statistics.

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Appendix

A. Summary Statistics

Table A.1. Summary statistics of selected commodities

HS Code: 7108.12		**Gold: Non-monetary, Other unwrought forms**			
	N	*Mean*	*Std. Dev.*	*Maximum*	*Minimum*
Quantity (kg)	55,986	273.0	775.5	13,764	0.00100
Value (CHF)	55,986	8,625,000	24,730,000	507,300,000	1
Unit Price (CHF/kg)	55,986	39,263	906,764	203,500,000	0.0614
HS Code: 7403.11		**Refined copper: Cathodes and sections of cathodes**			
	N	*Mean*	*Std. Dev.*	*Maximum*	*Minimum*
Quantity (kg)	359	12,095	11,992	31,460	0.0900
Value (CHF)	359	83,112	79,008	242,194	80
Unit Price (CHF/kg)	359	651.4	1,811	15,320	1.501
HS Code: 1801.00		**Cocoa beans, whole or broken, raw or roasted**			
	N	*Mean*	*Std. Dev.*	*Maximum*	*Minimum*
Quantity (kg)	13,121	22,190	21,693	246,875	0.0600
Value (CHF)	13,121	70,467	66,876	780,975	1
Unit Price (CHF/kg)	13,121	10.89	34.55	2,990	0.172
HS Code: 901.11		**Coffee, not roasted, not decaffinated**			
	N	*Mean*	*Std. Dev.*	*Maximum*	*Minimum*
Quantity (kg)	38,483	24,252	23,920	289,800	0.0440
Value (CHF)	38,483	102,892	103,471	1,890,000	1
Unit Price (CHF/kg)	38,483	6.171	30.91	5,227	0.0783
HS Code: 901.12		**Coffee, not roasted, decaffinated**			
	N	*Mean*	*Std. Dev.*	*Maximum*	*Minimum*
Quantity (kg)	3,890	18,136	10,110	60,000	0.165
Value (CHF)	3,890	101,764	63,944	334,208	2
Unit Price (CHF/kg)	3,890	8.859	40.38	2,098	0.0968

Note: Swiss Federal Customs Administration List of Tariff Headings document available here: https://www.ezv.admin.ch/ezv/en/home/information-companies/customs-tariff---tares.html (accessed: February, 2018)

B. Sensitivity Analysis with different free-market price filters

Table B.1.: Undervalued Imports – Unwrought Gold

Year	Import Value (CHF, million)	Minus 40% 30-day Moving Average (CHF, million)	Minus 30% (CHF, million)	Minus 50% (CHF, million)
2012	88,971	14,225	19,216	10,315
2013	109,612	13,274	17,065	9,927
2014	65,151	11,977	15,587	9,084
2015	68,220	14,528	18,029	11,437
2016	81,805	14,324	18,253	11,021
2017	69,096	13,913	17,603	10,797
Mean	**80,476**	**13,707**	**17,626**	**10,430**
Total	**482,857**	**82,242**	**105,753**	**62,582**

Data Source: Swiss Customs Administration; United Nations Comtrade
Notes: Product category includes unwrought gold (HS: 7108.12) imports for period 2012-17. Switzerland does not report gold trade data till 2011. Since this Customs product classification may also record unwrought gold ornaments and other gold products usually shipped in small quantities, we exclude transactions below 1 kilogram by weight (N=2,854). The objective is to focus on larger transactions of gold doré. **Free market price** is the daily Gold Bullion price from London Bullion Market (US$ per troy ounce, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table B.2.: Overvalued Imports – Unwrought Gold

Year	Import Value (CHF, million)	Plus 40% 30-day Moving Average (CHF, million)	Plus 30% (CHF, million)	Plus 50% (CHF, million)
2012	88,971	0.00	0.00	0.00
2013	109,612	0.00	0.02	0.00
2014	65,151	0.00	0.00	0.00
2015	68,220	3.90	4.46	3.61
2016	81,805	0.00	0.06	0.00
2017	69,096	0.00	0.00	0.00
Mean	**80,476**	**0.65**	**0.76**	**0.60**
Total	**482,857**	**3.90**	**4.54**	**3.61**

Data Source: Swiss Customs Administration; United Nations Comtrade
Notes: Product category includes unwrought gold (HS: 7108.12) imports for period 2012-17. Switzerland does not report gold trade data till 2011. Since this Customs product classification may also record unwrought gold ornaments and other gold products usually shipped in small quantities, we exclude transactions below 1 kilogram by weight (N=2,854). The objective is to focus on larger transactions of gold doré. **Free market price** is the daily Gold Bullion price from London Bullion Market (US$ per troy ounce, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table B.3.: Undervalued Imports: Refined Copper

Year	Import Value (CHF, million)	Minus 20% 30-day Moving Average (CHF, million)	Minus 10% (CHF, million)	Minus 30% (CHF, million)
2011	4.62	0.42	0.75	0.23
2012	4.89	0.00	0.11	-
2013	6.39	0.00	0.17	-
2014	5.76	0.03	0.32	0.01
2015	2.30	0.00	0.04	-
2016	2.55	-	-	-
2017	3.34	0.00	0.00	0.00
Mean	**4.26**	**0.07**	**0.20**	**0.03**
Total	**29.84**	**0.47**	**1.39**	**0.24**

Data Source: Swiss Customs Administration; United Nations Comtrade
Notes: Product categories include refined copper cathodes and sections of cathodes (HS: 7403.11) for period 2011-17. **Free market price** is the daily LME-Copper, Grade A price from London Metals Exchange (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table B.4.: Overvalued Imports - Refined Copper

Year	Import Value (CHF, million)	Plus 20% 30-day Moving Average (CHF, million)	Plus 10% (CHF, million)	Plus 30% (CHF, million)
2011	4.62	0.12	0.12	0.12
2012	4.89	0.20	0.24	0.18
2013	6.39	0.22	0.25	0.18
2014	5.76	0.05	0.05	0.05
2015	2.30	0.05	0.06	0.05
2016	2.55	0.09	0.10	0.09
2017	3.34	0.13	0.14	0.13
Mean	**4.26**	**0.12**	**0.14**	**0.11**
Total	**29.84**	**0.86**	**0.96**	**0.80**

Data Source: Swiss Customs Administration; United Nations Comtrade
Notes: Product categories include refined copper cathodes and sections of cathodes (HS: 7403.11) for period 2011-17. **Free market price** is the daily LME-Copper, Grade A price from London Metals Exchange (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table B.5.: Undervalued Imports - Cocoa Beans

Year	Import Value (CHF, million)	Minus 20% 30-day Moving Average (CHF, million)	Minus 20% (CHF, million)	Minus 40% (CHF, million)
2011	143.79	1.21	1.49	0.09
2012	133.49	0.26	0.03	0.00
2013	118.67	0.48	0.07	0.00
2014	130.69	1.24	1.43	0.00
2015	143.13	0.12	0.22	0.00
2016	125.06	0.09	0.08	0.00
2017	129.76	0.02	0.02	0.00
Mean	**132.08**	**0.39**	**0.48**	**0.01**
Total	**924.59**	**2.75**	**3.33**	**0.10**

Data Source: Swiss Customs Administration; United Nations Comtrade
Notes: Product category includes cocoa beans (HS: 1801.00) for period 2011-17. **Free market price** is the Cocoa-ICCO Daily Price (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table B.6.: Overvalued Imports - Cocoa Beans

Year	Import Value (CHF, million)	Plus 20% 30-day Moving Average (CHF, million)	Plus 20% (CHF, million)	Plus 40% (CHF, million)
2011	143.79	2.94	4.88	1.68
2012	133.49	14.15	13.66	4.87
2013	118.67	6.11	6.17	2.29
2014	130.69	0.96	1.01	0.63
2015	143.13	2.15	2.23	1.36
2016	125.06	4.63	5.50	2.85
2017	129.76	23.49	23.82	9.86
Mean	**132.08**	**7.78**	**8.18**	**3.36**
Total	**924.59**	**54.43**	**57.25**	**23.53**

Data Source: Swiss Customs Administration; United Nations Comtrade
Notes: Product category includes cocoa beans (HS: 1801.00) for period 2011-17. **Free market price** is the Cocoa-ICCO Daily Price (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table B.7.: Undervalued Imports - Coffee Beans, Not Roasted

Year	Import Value (CHF, million)	Minus 50% 30-day Moving Average (CHF, million)	Minus 40% (CHF, million)	Minus 60% (CHF, million)
2011	695.87	6.73	16.18	1.02
2012	660.38	0.53	2.01	0.03
2013	567.24	0.03	0.06	0.01
2014	567.51	1.49	6.03	0.14
2015	652.25	0.07	0.18	0.03
2016	582.98	0.05	0.56	0.01
2017	629.24	0.06	0.19	0.01
Mean	**622.21**	**1.28**	**3.61**	**0.18**
Total	**4,355.47**	**8.95**	**25.28**	**1.26**

Data Source: Swiss Customs Administration; United Nations Comtrade
Notes: Product categories include coffee beans, not roasted, decaffeinated and not-decaffeinated (HS: 901.11 and 901.12) for period 2011-17. **Free market price** is the International Coffee Organization ICO Daily Price (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table B.8.: Overvalued Imports - Coffee Beans, Not Roasted

Year	Import Value (CHF, million)	Plus 50% 30-day Moving Average (CHF, million)	Plus 40% (CHF, million)	Plus 60% (CHF, million)
2011	695.87	9.93	19.00	7.83
2012	660.38	44.98	71.05	35.33
2013	567.24	41.15	62.03	30.88
2014	567.51	12.88	20.77	9.14
2015	652.25	91.56	121.07	75.68
2016	582.98	55.58	71.75	42.72
2017	629.24	56.89	80.54	43.61
Mean	**622.21**	**44.71**	**63.75**	**35.03**
Total	**4,355.47**	**312.98**	**446.22**	**245.20**

Data Source: Swiss Customs Administration; United Nations Comtrade
Notes: Product categories include coffee beans, not roasted, decaffeinated and not-decaffeinated (HS: 901.11 and 901.12) for period 2011-17. **Free market price** is the International Coffee Organization ICO Daily Price (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

C. Data Comparison: Swiss Federal Customs and UN Comtrade Database

Table C.1.: Unwrought Gold – Swiss Customs and UN Comtrade

Year	Import Value Swiss Customs (CHF, million)	Swiss Imports UN Comtrade (CHF, million)	RoW Exports UN Comtrade (CHF, million)	Partner-country Method: Swiss Imports - RoW Exports (CHF, million)
2012	88,975	85,473	57,515	22,206
2013	109,615	103,886	34,475	65,963
2014	65,153	60,587	32,150	25,221
2015	68,211	62,292	27,346	32,212
2016	81,807	73,150	35,091	34,549
2017	69,100	68,368	27,717	37,879
Mean	**80,480**	**75,626**	**35,716**	**36,338**
Total	**482,879**	**453,760**	**214,297**	**218,032**

Data Source: Swiss Customs Administration; United Nations Comtrade
Notes: Product category includes unwrought gold (HS: 7108.12) for period 2012-17. Switzerland does not report gold trade data till 2011. **Free market price** is the daily Gold Bullion price from London Bullion Market (US$ per troy ounce, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table C.2.: Refined Copper – Swiss Customs vs UN Comtrade

Year	Import Value Swiss Customs (CHF, million)	Swiss Imports UN Comtrade (CHF, million)	RoW Exports UN Comtrade (CHF, million)	Partner-country Method: Swiss Imports - RoW Exports (CHF, million)
2011	4.62	4.52	3,391	3,725
2012	4.89	4.71	3,262	3,583
2013	6.39	6.04	3,341	3,669
2014	5.76	5.36	3,529	3,876
2015	2.30	2.13	2,357	2,590
2016	2.55	2.32	274	299
2017	3.34	3.34	236	256
Mean	**4.26**	**4.06**	**2,341**	**2,571**
Total	**29.84**	**23.89**	**16,392**	**18,003**

Data Source: Swiss Customs Administration; United Nations Comtrade
Notes: Product categories include refined copper cathodes and sections of cathodes (HS: 7403.11) for period 2011-17. **Free market price** is the daily LME-Copper, Grade A price from London Metals Exchange (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table C.3.: Cocoa Beans – Swiss Customs vs UN Comtrade

Year	Import Value Swiss Customs (CHF, million)	Swiss Imports UN Comtrade (CHF, million)	RoW Exports UN Comtrade (CHF, million)	Partner-country Method: Swiss Imports - RoW Exports (CHF, million)
2011	143.79	140.91	22.91	115.71
2012	133.49	128.49	31.59	93.74
2013	118.67	112.29	14.95	95.85
2014	130.69	121.53	14.57	105.50
2015	143.13	132.44	9.99	121.45
2016	125.06	113.71	4.65	108.60
2017	129.76	129.79	3.87	125.53
Mean	**132.08**	**123.04**	**13.27**	**109.48**
Total	**924.59**	**738.25**	**79.62**	**766.38**

Data Source: Swiss Customs Administration; United Nations Comtrade
Notes: Product category includes cocoa beans (HS: 1801.00) for period 2011-17. **Free market price** is the Cocoa-ICCO Daily Price (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.

Table C.4.: Coffee Beans, Not Roasted – Swiss Customs vs UN Comtrade

Year	Import Value Swiss Customs (CHF, million)	Swiss Imports UN Comtrade (CHF, million)	RoW Exports UN Comtrade (CHF, million)	Partner-country Method: Swiss Imports - RoW Exports (CHF, million)
2011	695.87	681.92	386.56	256.70
2012	660.38	635.62	280.88	326.66
2013	567.24	536.75	230.68	283.00
2014	567.51	527.74	174.89	335.36
2015	652.25	604.15	174.04	412.71
2016	582.98	530.03	162.30	351.49
2017	629.24	629.25	112.80	505.17
Mean	**622.21**	**592.21**	**217.45**	**353.01**
Total	**4,355.47**	**4,145.46**	**1,522.15**	**2,471.09**

Data Source: Swiss Customs Administration; United Nations Comtrade
Notes: Product categories include coffee beans, not roasted, decaffeinated and not-decaffeinated (HS: 901.11 and 901.12) for period 2011-17. **Free market price** is the International Coffee Organization ICO Daily Price (US$ per metric ton, converted to CHF per kilogram using daily US$-CHF exchange rate). **Interquartile range** is calculated for unit prices (CHF per kg) using transaction-level Swiss Customs data. **Partner-country trade gaps** equal the difference between annual imports from rest of the world by Switzerland and reported exports by rest of the world to Switzerland (US$ converted to CHF using annual average exchange rate from UNCTADStat). This difference can be either positive or negative, implying either over-valued or under-valued imports in any given year.