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# Using unit value indices as proxies for international merchandise trade prices

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# *Using unit value indices as proxies for international merchandise trade prices*

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*Abstract*

In light of the need for detailed and timely internationally comparable trade price indices, this paper describes a multi-tiered methodology to mitigate many of the empirical challenges associated with using customs data, to provide more robust estimates of unit value indices (UVIs) by country and product. UVIs are available for both exports and imports, by reporting country and the CPA 2-digit level of classification. Although the approach cannot capture changes in the quality of products nor compositional changes happening at a lower than HS 6-digit classification, the results indicate that at higher levels of aggregation (SITC 1-digit level), estimated UVIs closely follow price changes obtained from other sources. This is observed both for products with significant and rapid quality changes, such as hi-tech products, and for products with a low rate of quality changes, such as commodities, other primary and low-tech goods. Furthermore, products where little quality change occurs over time show similarity between UVIs and price changes from other sources at lower levels of disaggregation. The methodology is used to produce the Merchandise Trade Price Index and the data is made publically available on .Stat under the International Trade and Balance of Payments heading.

*Keywords: Unit value, international trade, outlier removal, international trade price indices.*

*JEL Classification: C43, C82, E31.*

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*Résumé*

Compte tenu de la nécessité de disposer d'indices des prix du commerce détaillés et actualisés, comparables au niveau international, cet article décrit une méthodologie à plusieurs niveaux permettant d'atténuer bon nombre des difficultés empiriques liées à l'utilisation des données douanières, afin de fournir des estimations plus robustes des indices de valeur unitaire (IVU) par pays et par produit. Les indices IVU sont disponibles pour les exportations et les importations, par pays déclarant et par niveau de classification à deux chiffres de la CPA. Bien que l'approche ne puisse pas capturer les changements de qualité des produits ni les changements de composition à un niveau plus fin de désagrégation que la décomposition HS à six chiffres, les résultats indiquent qu'à des niveaux d'agrégation plus élevés (niveau à un chiffre de la CTCI), les IVU estimés suivent de près les changements de prix obtenus à partir d'autres sources. Ceci est observé à la fois pour les produits dont la qualité change de manière significative et rapide, tels que les produits à haute technologie, ainsi que pour les produits dont la qualité change peu, tels que les produits de base, les autres produits primaires et les produits à faible technologie. En outre, les produits dont la qualité change peu au fil du temps présentent des similitudes entre les indices IVU et les variations de prix provenant d'autres sources à des niveaux de désagrégation inférieurs. La méthodologie discutée est utilisée pour produire l'indice des prix du commerce des marchandises et les données sont rendues publiques sur .Stat sous la rubrique Commerce international et balance des paiements.

*Mots clés: Valeur unitaire, commerce international, élimination des valeurs aberrantes, indices des prix du commerce international.*

*Classification JEL : C43, C82, E31.*

# *Table of contents*



## FIGURES

## TABLES

## 1. Introduction

At the core of nearly all standard economic analyses is the ability to differentiate between volume and price effects. This is equally pertinent for statistics on international trade. However, despite the growing importance of international trade, the availability of statistics on price changes that go beyond aggregated measures can at best be described as patchy.

Nearly all countries provide measures of **overall** price change in international trade, typically broken down by goods and services, as part of their volume measures of GDP. However, a few countries provide trade price indices for the main (SITC) aggregated product groups, and even fewer provide estimates at more detailed product level (i.e. at 2-digit CPA level). The lack of timely trade price indices, especially at the **detailed** product level, has increasingly become the focus of trade policy and trade analyses.

More granular estimates of price changes can be obtained from merchandise trade statistics collected by customs authorities. These data include information on quantities of the transactions to complement nominal values, broken down by product and trading partner, therefore provide a means to create Unit Value Indices (UVIs) as proxies for import and export price indices.

Indeed, to compute their national-account estimates of trade in volume, many countries adopt the UVI approach. However, the use of customs data is not without challenges: UVIs often mix non-homogeneous products even at the finest level of classification, and are not able to capture price changes in goods that are subject to significant quality changes over time (see also Bradley, 2005; Silver 2007, 2010; and von den Lippe, 2010). In addition, confidentiality rules hide certain trade products, which make prices and price changes untraceable. Lastly, ILO et al. (2009) also clearly explain the shortcoming of UVIs including the possible bias they introduce, but also admit that UVIs are still useful when survey based approaches are infeasible or too costly, as is the case in this study.

From a conceptual point of view, the inability to capture quality change is an important shortcoming in creating volume measures of merchandise trade using UVIs. However, many traded products, such as commodities, are not significantly affected by quality changes. Moreover, even when quality changes occur within the same classification grouping, for example through the introduction of new upgraded products, the new products are often introduced in small quantities initially relative to the goods that are gradually being displaced – meaning that the impact of the quality change on price measurement is spread over a number of periods. In addition, a significant part of the quality change in many products reflects design and brand, the value of which is often only captured when the product is sold to its final market (and not always captured in export F.O.B or import C.I.F prices).[2]

Often, it is not the inability to capture these quality changes that impede the take-up and use of customs data, but, rather, the inability to control for compositional changes and the underlying quality of quantity data – their coherence with nominal values and their comparability over time and across

[2] A number of studies have looked to estimate quality change in trade based UVIs, see, for example, Schott (2004, 2008), Hallak (2006), Hallak & Shott (2011), Khandelwal (2010), Martin & Mejean (2010), Feenstra & Romanlis (2014), and Ahmad (2019).

countries – which can be witnessed in the often wide, and arguably implausible, variation in unit values for certain individual products at most detailed (HS 6-digit) level.[3]

Addressing these data quality issues to derive more robust measures of UVIs from customs statistics is, therefore, the focus of this paper. The remainder of this paper is organised as follows. Section 2 describes the empirical methodology in detail, including in particular the steps taken to mitigate some of the source data limitations. The results are presented in Section 3, which includes comparisons with other data sources and national accounts benchmark estimates. Section 4 provides examples of how the newly estimated price indices can be used for analytical purposes and how potentially prices develop along GVCs. Section 5 concludes.

## 2. Data and methodology

Trivial as it may seem, constructing unit value indices (UVIs) from detailed merchandise trade data requires an intricate process of data cleaning and outlier removal. The key challenge is to identify and exclude unrealistic **prices** and **price changes** while ensuring that these indices are representative of the underlying trade transactions.

The common practice in creating national UVIs, drawing only on national data (imports and exports by partner and product), is to retain those export or import unit values that are close to the observed median for a given product, and sometimes, it is done in combination with other quality checks. Earlier OECD work followed countries' best practices using the Asymmetric Fence Method (AFM) and the revised Mean Absolute Deviation (MAD) methods for outlier detection.[4] WTO and UNCTAD also publish trade in volume indices and unit value indices at aggregated level, which are either estimated in house or sourced from national and international sources.

Gaulier et al. (2008) focused on unit value changes and retained only those UVIs between 0.2 to 5. Berthou & Emlinger (2011) combined the two approaches, by screening out unit values that were 100 times higher or lower than the median, and UVIs that were less than a factor of 0.0001 or greater than 1 000 times those in the previous year.

Building on and refining the methodology introduced in the previous studies, this paper proposes a three-stage process to detect outliers before constructing UVIs at various levels of disaggregation. In addition, the proposed outlier detection method also takes into account exchange rate fluctuations.

[3] Earlier OECD studies (Mendez et al., 2014; Wistrom and Sarrazin, 2012; Wistrom and Serve, 2011) also revealed significant differences between UVIs reported by country and published commodity price indices.

[4] Usually, AFM is used for groupings with more than 100 observations and MAD for less than 100.

## 2.1. Data sources

The key data used are the detailed merchandise trade statistics at the HS 6-digit product level, by reporter and partner, which are sourced from the UN Comtrade database. As the target years for this research spanned the period 2010 to 2020, trade flows are reported in three different classifications, namely HS2007, HS2012, and HS2017. To avoid breaks in time series, only products with a 1:1 concordance between the three classifications were selected, covering 93% of products.[5] At the time of writing, about 50% of countries submitted their 2019 and 2020 merchandise trade data to UN. Therefore, the estimates for these two years should be treated as provisional.

To provide some form of quality assurance for the UVIs estimated from UN Comtrade, these are compared to three additional sources:

- *National accounts implicit trade price deflator*: Statistics on the exports and imports of goods, or of goods and services (if not separately reported), in current and in previous year's prices (PYP) are collected from the OECD, UNSD and Eurostat's national accounts database, as well as from national statistical offices. The implicit price indices are calculated as reported current prices over PYP in national currency. Implicit price indices are derived for the exports and imports of *goods* for 106 countries, and for the exports and imports of *goods and services* for 86 countries where price indices could only be derived at aggregated levels (see Section 3.1).

- *Trade price indices released by national statistical office:* For some countries, annual trade price indices are also available at SITC 1-digit level (10 product groups), which allows for a comparison with the UVIs developed in this paper. The three countries for which data are available – Germany, Australia and Canada – have different methodologies for estimating trade prices and price changes (see Section 3.1).

- *World Bank Global Economic Monitor Key Commodities Price:* It offers global reference prices for key commodities, such as copper, petroleum (separated into various categories such as crude oil, Brent; crude oil, Dubai; and crude oil, West Texas Intermediates)., cotton, cocoa, and other kinds of primary goods, which are frequently traded on global markets. These products can be closely matched with certain HS classifications at 4-digit level (see section 3.2 and Annex D).

Exchange rates are sourced from various databases, including UNSD, World Development Indicators, Penn World Tables, and from national statistical offices. International merchandise trade data reported to the UN can be either in USD or in national currency unit (NCU). UNSD has harmonised these trade data (into USD) by applying appropriate exchange rates, which are published separately as metadata. We use these metadata to convert trade flows in USD to NCU. If exchange rates are not already included in the metadata (i.e. country reported trade flows in USD), data gaps are filled by using the exchange rates

[5] Correspondence tables are available on UN website: https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp.

from World Development Indicators, Penn World Tables or national statistical offices.

## 2.2. Methodology

In constructing merchandise trade unit values indices, the methodology for detecting outliers entails a fine balancing act to identify unit values that should be considered as noise (and hence removed from further calculations) and plausible unit value changes.

A key decision to make in this context concerns the level of disaggregation at which outlier detection is conducted. As noted above, merchandise trade data are available broken down by product and partner country, and, in theory, outlier detection should be applied within product (HS 6-digit level), reporter and partner stratum. However, in practice, it means that only one or limited number of observations are in each stratum, inhibiting any meaningful attempts at identifying outliers.

Indeed, the balance of stratification and product heterogeneity is a "fine-art", or a "philosophical debate" for this statistical puzzle. The heterogeneous nature of products exists in the well-defined HS 6-digit classification, even at 8-digit or 10-digit level, so UVIs, as a result, may measure quality changes that bundled composition changes and price changes at the same time. However, going to the most detailed records for outlier detection results in low trade frequency, and the statistics based on such limited trading records hit small sample bias and run into bimodal distribution problems easily.

Therefore, for this research, the stratum for outlier detection is defined by HS 4-digit product and quantity unit, which allows for a sufficient number of observations (to avoid small sample bias), while still maintaining a reasonable degree of product homogeneity[6] (see Annex C for the quantity codes used in UN COMTRADE and their reporting frequency). UVIs are estimated by reporter and product, but not by partner.[7]

A three-stage outlier removal procedure was used to identify outliers:

1. in unit values,
2. in unit value changes over time, and
3. in unit value changes across countries.

In the ***first*** stage, all HS 6-digit unit values are grouped into strata defined by HS 4-digit product, quantity unit and year (i.e. pooling data across countries and

[6] Gaulier et al. (2008) and Berthou & Emlinger (2011) introduced a conversion for goods reported other than kilogrammes, and converted all other quantity codes to kilogrammes using mirrored flows reported in more than one quantity, but this data-driven solution assumes good quality mirror statistics (some recent empirical research carried out by the OECD suggested otherwise).

[7] While it is feasible to develop indices by trading partner, this would come at the cost of either the loss of statistical power (i.e. running into small sample problem quickly), or a higher level of product aggregation (i.e. increase more tolerance for product heterogeneity). Further research may aim to elaborate price indices with breakdowns by partner countries for the frequent reporters and partners where sufficient number of observations can be drawn from UN Comtrade database.

partners). Outliers are identified and removed using the AFM method (see Box 1) in line with previous OECD studies and examples set by OECD countries. The unit value of a product (observed at the HS 6-digit level) is removed if it is too high or too low compared to other products in the same stratum. For the distribution of unit values for selected products, please refer to Annex A.

In the ***second*** stage, observations with implausible year-on-year price changes are removed, where 'implausible' is defined as any observation where the unit value change (relative to the previous year) is lower than 0.2 or higher than 10 in both US dollar and national currency, and ***only if*** the corresponding trade flow amounts to less than 10% of trade value in the stratum. The latter criterion is to avoid automatically screening out large flows (checked manually), as it will have a systematic and significant impact on unit value changes. Observations for any given country-partner-product mix that are reported using different quantity units over time (e.g. kilogrammes in one year and numbers of units in the following year) are also removed.

In the ***third*** stage, a comparison of price changes at 6-digit is made across countries and partners within their respective strata. As in the second stage, the observations that account for more than 10% of trade in each stratum are also preserved and checked manually.

Taking rice (HS1006) as an example, Table 2.1 shows that the unit value of rice per kilogramme according to UN Comtrade ranges from near zero in the lower bound to USD 493 thousand in the upper bound. It is not easy to gauge which prices are realistic and which prices are not and therefore to separate false positives from true negatives: potentially some countries indeed pay exorbitant prices for rice under certain circumstances. The cut-off line needs to be drawn somewhere: the AFM criteria is used in the first stage of outlier detection to identify and remove those unit value prices that are more likely implausible when comparing with unit values of rice imported by other countries.

## Table 2.1. Unit value before and after the first stage of outlier detection, rice imports - AFM method, USD per kilogramme

| | Observed range of unit value for Rice (HS 1006) | | Accepted range after stage 1 | |
|---|---|---|---|---|
| | UV lower bound | UV upper bound | UV lower bound | UV upper bound |
| 2010 | 0.00 | 6607.38 | 0.38 | 3.96 |
| 2011 | 0.00 | 659.13 | 0.38 | 4.00 |
| 2012 | 0.00 | 493620.00 | 0.40 | 3.95 |
| 2013 | 0.00 | 501.00 | 0.37 | 3.88 |
| 2014 | 0.00 | 5691.25 | 0.37 | 4.38 |
| 2015 | 0.00 | 7903.75 | 0.35 | 3.97 |
| 2016 | 0.00 | 3876.00 | 0.33 | 3.78 |
| 2017 | 0.00 | 266.16 | 0.36 | 3.78 |
| 2018 | 0.00 | 589.00 | 0.35 | 3.65 |
| 2019 | 0.00 | 350.00 | 0.33 | 3.74 |
| 2020 | 0.00 | 534.00 | 0.38 | 3.74 |

Note: About 50% of countries have submitted their 2019 and 2020 trade data to UN Comtrade at the time when data are processed. Therefore, the results for these two years should be treated as provisional.
Source: Authors' calculation using UN Comtrade data.

The second stage of outlier detection, carrying on with the rice example, removes unit value changes (expressed as the ratio of unit value at time t and t- 1) above 10 or less than 0.2 in both NCU and USD (see Table 2.2), except for the observations representing over 10% of total trade in their respective strata.

The third stage of outlier detection brings the remainder of unit value changes together within the same stratification and uses AFM outlier detection again to further remove implausible changes in both NCU and USD. The third and final cut-off ranges for rice imports, using 2020 data as an example, are 0.70~1.36 in USD, and 0.79~1.71 in NCU (Table 2.3).

## Table 2.2. UVI before and after the second stage of outlier detection, rice imports - AFM method

| | Before second stage of outlier detection | | | | After second stage of outlier detection | | | |
|---|---|---|---|---|---|---|---|---|
| | UVI in NCU | | UVI in USD | | UVI in NCU | | UVI in USD | |
| | Lower Bound | Upper Bound | Lower Bound | Upper Bound | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| 2011 | 0.11 | 7.02 | 0.11 | 7.24 | 0.20 | 7.02 | 0.21 | 7.24 |
| 2012 | 0.13 | 133.31 | 0.12 | 7.98 | 0.20 | 7.94 | 0.18 | 7.98 |
| 2013 | 0.13 | 8.87 | 0.14 | 7.38 | 0.20 | 8.87 | 0.20 | 7.38 |
| 2014 | 0.13 | 16.51 | 0.13 | 11.06 | 0.21 | 9.17 | 0.17 | 9.16 |
| 2015 | 0.02 | 10.05 | 0.10 | 8.59 | 0.05 | 10.05 | 0.18 | 8.59 |
| 2016 | 0.09 | 32.17 | 0.09 | 7.85 | 0.20 | 32.17 | 0.16 | 7.85 |
| 2017 | 0.12 | 9.48 | 0.11 | 9.69 | 0.19 | 9.48 | 0.20 | 9.69 |
| 2018 | 0.00 | 13.65 | 0.13 | 8.16 | 0.00 | 13.65 | 0.18 | 8.16 |
| 2019 | 0.12 | 12.43 | 0.11 | 9.01 | 0.21 | 12.43 | 0.20 | 9.01 |
| 2020 | 0.13 | 11.42 | 0.12 | 9.10 | 0.21 | 11.42 | 0.21 | 9.10 |

Note: About 50% of countries have submitted their 2019 and 2020 trade data to UN Comtrade at the time when data are processed. Therefore, the results for these two years should be treated as provisional.
Source: Authors' calculation using UN Comtrade data.

## Table 2.3. UVI after the third stage of outlier detection, rice imports - AFM method

| | | **After third stage of outlier detection** | | | |
|---|---|---|---|---|---|
| | | UVI in NCU | | UVI in USD | |
| | No. Obs. | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| 2011 | 2083 | 0.68 | 2.18 | 0.65 | 1.50 |
| 2012 | 2184 | 0.74 | 2.70 | 0.56 | 1.41 |
| 2013 | 2308 | 0.77 | 1.68 | 0.69 | 1.33 |
| 2014 | 2517 | 0.76 | 1.94 | 0.53 | 1.44 |
| 2015 | 2648 | 0.08 | 2.15 | 0.48 | 1.36 |
| 2016 | 2647 | 0.68 | 11.70 | 0.59 | 1.37 |
| 2017 | 2663 | 0.71 | 1.84 | 0.63 | 1.46 |
| 2018 | 2544 | 0.00 | 4.72 | 0.52 | 1.45 |
| 2019 | 2423 | 0.79 | 2.08 | 0.57 | 1.39 |
| 2020 | 2299 | 0.79 | 1.71 | 0.70 | 1.36 |

Note: About 50% of countries have submitted their 2019 and 2020 trade data to UN Comtrade at the time when data are processed. Therefore, the results for these two years should be treated as provisional.
Source: Authors' calculation using UN Comtrade data.

### Box 1. Asymmetric Fence Method and revised mean absolute deviation and sensitivity analysis

The Asymmetric Fence Method (AFM) is recommended for use within groups with more than 100 observations and identifies as outliers all observations that meet the following criteria:

$$OR \begin{cases} q_1 - {uv^i}_{hs6} > K_{AFM} * max(q_2 - q_1, c * |q_2|) \\ {uv^i}_{hs6} - q_3 > K_{AFM} * max(q_3 - q_2, c * |q_2|) \end{cases}$$

where ${uv^i}_{hs6}$ is the logarithm of the unit value (at 6-digit level). $q_1, q_2$ and $q_3$ correspond to the first, the second, and the third quartiles of the population distribution of the log unit value within HS 4-digit – quantity type group. $K_{AFM}$ and $c$ are pre-set parameters, with $c = 0.05$ and $K_{AFM} = 1$.

The Revised Mean Absolute Deviation (MAD) is recommended for use in groups with less than 100 observations and identifies as outliers all observations that meet the following criteria:

$$AND \begin{cases} \left|{uv^i}_{hs6} - q_2\right| > K_{MAD} * MAD_{hs6} \\ \left|exp\left({uv^i}_{hs6}\right) - exp(q_2)\right| > A * |exp(q_2)| \end{cases}$$

where with $MAD_{hs6} = median\left|{uv^i}_{hs6} - q_2\right|$, A=0.1 and $K_{MAD} = 2$.

The parameters used here are suggested by several authors (Mendez et al., 2014; Wistrom & Sarrazin, 2012; Wistrom & Serve, 2011; Anitori, 2011; Zetina, 2011). Robustness tests are also performed using different parameters (i.e. double or half K and c) in AFM method, taking rice imports data as an example. Indeed, UVIs is sensitive to the choice of K for certain countries but insensitive to the choice of c (see Annex G).

It is important to note that the first outlier detection for unit values is based only on cross-country comparisons of unit value levels in US dollars. The second and third stages of the outlier detection, on the other hand, compare the unit value changes with other products in the same 4-digit strata in **USD** and **NCU**, and are only removed if they appear as 'outliers' in **both**.[8] Even though many international trade deals are conducted in USD, national trade price indices, as reflected in countries' official statistics, are typically expressed in national currencies, as this best describes the extent to which price changes in domestic markets. For example, a currency depreciation makes imports more expensive, resulting in higher prices for businesses and consumers.

Table 2.4 summarises data coverage after each stage of outlier detection, with breakdowns by country groups according to their trade frequencies. It shows that the 50 countries in the first tier with highest trade frequencies (hereafter referred to as Tier 1, see also Annex B) between 2011 and 2020 in exports and imports account for about 92% of global trade, and quantity information are available for nearly 90% of reported trade flows.

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[8] This reflects the fact that countries/firms can choose to capitalise, for example, on a depreciating currency by raising profits (i.e. by increasing prices in national currencies) or by increasing market share (i.e. by keeping prices fixed in national currencies, in other words reducing them in USD). This is particularly relevant for countries with high (and in some cases hyper) inflation.

The first stage of outlier detection (based on unit values of products) results in a range of observations equivalent to 88% of total trade for both imports and exports, where quantities are available. The second and third stages (based on unit value changes) reduced the coverage further to over 70% for both imports and exports for these countries (which may reflect the changes in reporting quantity code).

## Table 2.4. Trade coverage after outlier detections, 2011-2020

Countries are grouped according to their number of trade transactions

| Country groups | Average number of observations per country | Share in total world trade | Average share of observations for which UV are available | | | |
|---|---|---|---|---|---|---|
| | | | Total* | After outlier detection phase 1** | After outlier detection phase 2** | After outlier detection phase 3** |
| Exports | | | | | | |
| Frequent traders (rank 1-50) | 1,012,580 | 91.9% | 88.8% | 87.6% | 79.1% | 73.2% |
| In-between (rank 51-100) | 117,102 | 5.8% | 93.8% | 83.8% | 69.1% | 61.5% |
| Least frequent traders | 14,909 | 2.3% | 90.1% | 75.4% | 55.4% | 48.5% |
| Unweighted Average | 327,370 | | 90.8% | 81.3% | 66.2% | 59.4% |
| Imports | | | | | | |
| Frequent traders (rank 1-50) | 744,731 | 91.7% | 88.8% | 88.0% | 80.2% | 73.9% |
| In-between (rank 51-100) | 362,609 | 6.4% | 91.7% | 84.7% | 71.9% | 63.8% |
| Least frequent traders | 115,023 | 1.9% | 87.7% | 81.4% | 61.4% | 52.3% |
| Unweighted Average | 364,254 | | 89.1% | 84.2% | 69.8% | 61.8% |

Note: Only HS 6-digit product codes where there is a one-to-one map among three HS classifications are selected. Data may not add up to 100% due to rounding.
* The denominator used in calculating shares is the total trade flow. For example, 89% of trade values have quantity information where unit value can be calculated.
** The denominator used based on the trade flows where unit value is available. In other words, it reflects only trade flows where quantities and trade values are available at the same time.
Source: Authors' calculation using UN Comtrade data.

For countries with lower frequency of trade[9] (accounting for merely 2% of global trade), the removal of outliers reduces the number of observations to 52% for imports and 49% for exports. These figures, of course, vary depending on the trading country, product and reporting year. Mozambique is classified as least-frequent traders, therefore the share of trade values can be used to calculate unit value indices is also low. Taking Mozambique's rice imports as an example,

[9] These countries trade significantly less than the frequently traded countries meaning that observations are not always available over two consecutive periods. Exacerbating this is the possibility that these countries may also have less reliable trade data (as indicated by the measures of asymmetry used in the OECD's database of balanced merchandise trade https://stats.oecd.org/Index.aspx?DataSetCode=BIMTS_CPA). In addition, this group of countries tend to have higher levels of inflation, although the dual approach (dollars and national currencies) to calculating unit value change mitigates the excessive removal of observations. Future research will look to investigate the scope of normalised outlier detection by explicitly introducing a broad inflation normalising factor.

as shown in Table 2.5, data reporting quality is good during 2012-2015, where all observations included quantity codes (kilogrammes) and quantity information (how many kilogrammes). But the quality of the reporting has dropped significantly since 2015 – generally below 3% of trade flows have quantity code and quantity. After three stages of outlier detection, the best trade coverage for calculating Mozambique rice import unit value indices is 21.5% in 2015 and the worst is 0% in 2019.

### Table 2.5. Mozambique rice imports, unit value indices and total trade value available in USD and shares

| | Trade value | Trade value with quantity code available | After stage 1 | After stage 2 | After stage 3 | Share with quantity available | After stage 1* | After stage 2* | After stage 3* |
|---|---|---|---|---|---|---|---|---|---|
| 2012 | 94,475,810 | 94,475,810 | 82,958,850 | - | - | 100.0% | 87.8% | 0.0% | 0.0% |
| 2013 | 248,729,390 | 248,729,390 | 23,751,970 | 20,475,310 | 1,140,430 | 100.0% | 9.5% | 8.2% | 0.5% |
| 2014 | 187,361,270 | 187,361,270 | 74,437,440 | 16,425,150 | 14,996,700 | 100.0% | 39.7% | 8.8% | 8.0% |
| 2015 | 152,350,653 | 152,347,519 | 60,922,853 | 55,742,141 | 32,826,572 | 100.0% | 40.0% | 36.6% | 21.5% |
| 2016 | 139,436,774 | 1,066,403 | 148,936 | 125,458 | 121,540 | 0.8% | 14.0% | 11.8% | 11.4% |
| 2017 | 187,487,273 | 4,909,511 | 2,288,671 | 31,514 | 14,353 | 2.6% | 46.6% | 0.6% | 0.3% |
| 2018 | 221,176,583 | 2,597,346 | 72,238 | 51,310 | 4,163 | 1.2% | 2.8% | 2.0% | 0.2% |
| 2019 | 240,369,587 | 887,853 | 835,339 | 18,818 | - | 0.4% | 94.1% | 2.1% | 0.0% |
| 2020 | 250,594,119 | 3,191,133 | 261,143 | 66,093 | 12,375 | 1.3% | 8.2% | 2.1% | 0.4% |

Note: * The denominator used based on the trade flows where unit value is available. In other words, it reflects only trade flows where quantities and trade values are available at the same time.
Source: Authors' calculation using UN Comtrade data.

## 3. Results and validation

This section summarises unit value indices (UVIs) at multiple levels of aggregation, namely by HS 4-digit, HS 3-digit, HS 2-digit, CPA 2-digit, SITC 1-digit, ISIC rev. 4 and cross tabulate of ISIC rev. 4 and end-use category. All UVIs are estimated as the weighted average of changes at HS 6-digit products using both Laspeyres (previous year's trade value as weight) and Paasche (current year's trade value as weight) formulae. Both Paasche and Laspeyres price indices were calculated with AFM and MAD outlier detection methods. As expected, differences between the various approaches proved to be negligible. The remainder of this paper presents only the results for Laspeyres indices using the AFM approach.

First, the estimated UVIs are compared with:

- national accounts implicit price deflators, and with more detailed price statistics in selected countries where data are available (section 3.1); and
- World Bank key commodity prices indices (section 3.2).

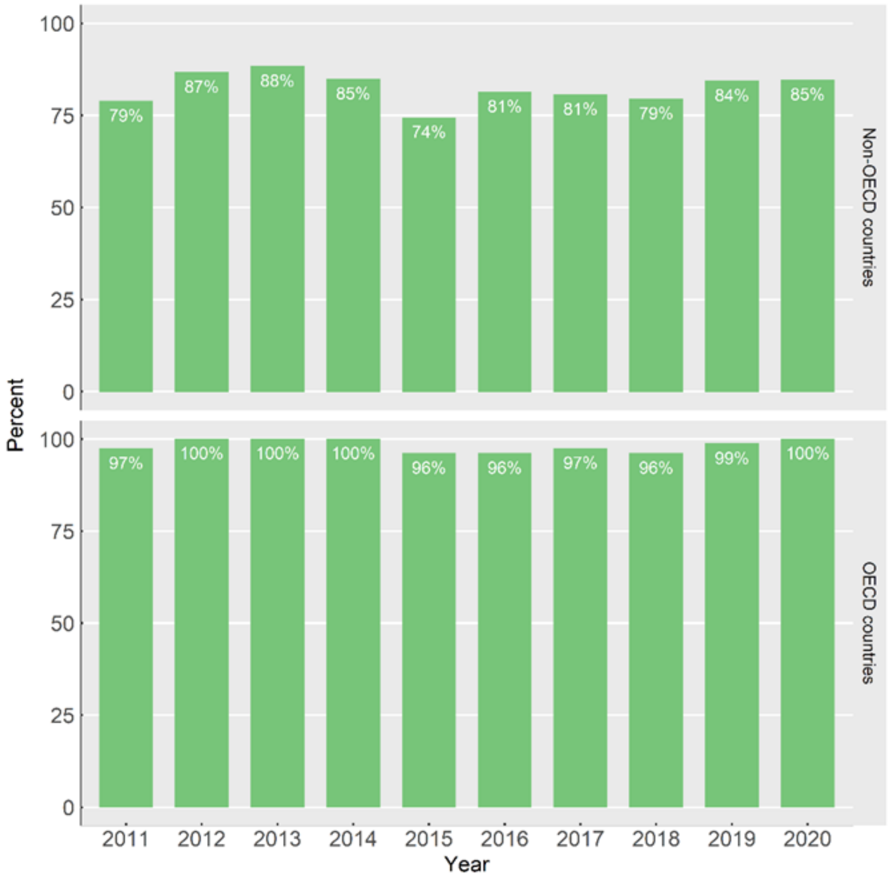
Second, the rest of this section presents the UVIs that result from the screening approaches described in Section 2 and subsequently benchmarked to the implicit price indices as published by national statistical offices (NSOs) (section 3.3 - 3.5).

## 3.1. Comparisons with implicit price indices from official statistics

### *Comparisons with aggregated national accounts deflators*

The estimated UVIs, once calculated at the aggregate level, appear to compare well with the implicit price deflators from national accounts. For those countries where deflators can be derived for goods, 86% of all observations have less than a 10% difference, which means price ratios are within +/- 0.1-point difference. For countries with less frequent trade data or potentially having high inflation or less reliable implicit prices, the UVIs do not match well with what is reported in their national accounts. For example, it is the case for Iran and Mauritania. Overall, import UVIs are better matched to national accounts implicit price deflators than export UVIs, and OECD countries show better match than non-OECD countries (Figure 3.1).

**Figure 3.1. Distance to implicit price indices: percentage of observations under 10% differences**




Note: Statistics are obtained by pooling both import and export values. This applies to 38 OECD member countries.
Source: Implicit price indices are soured from OECD, UNSD, Eurostat, and NSOs. UVIs are estimated using UN Comtrade.

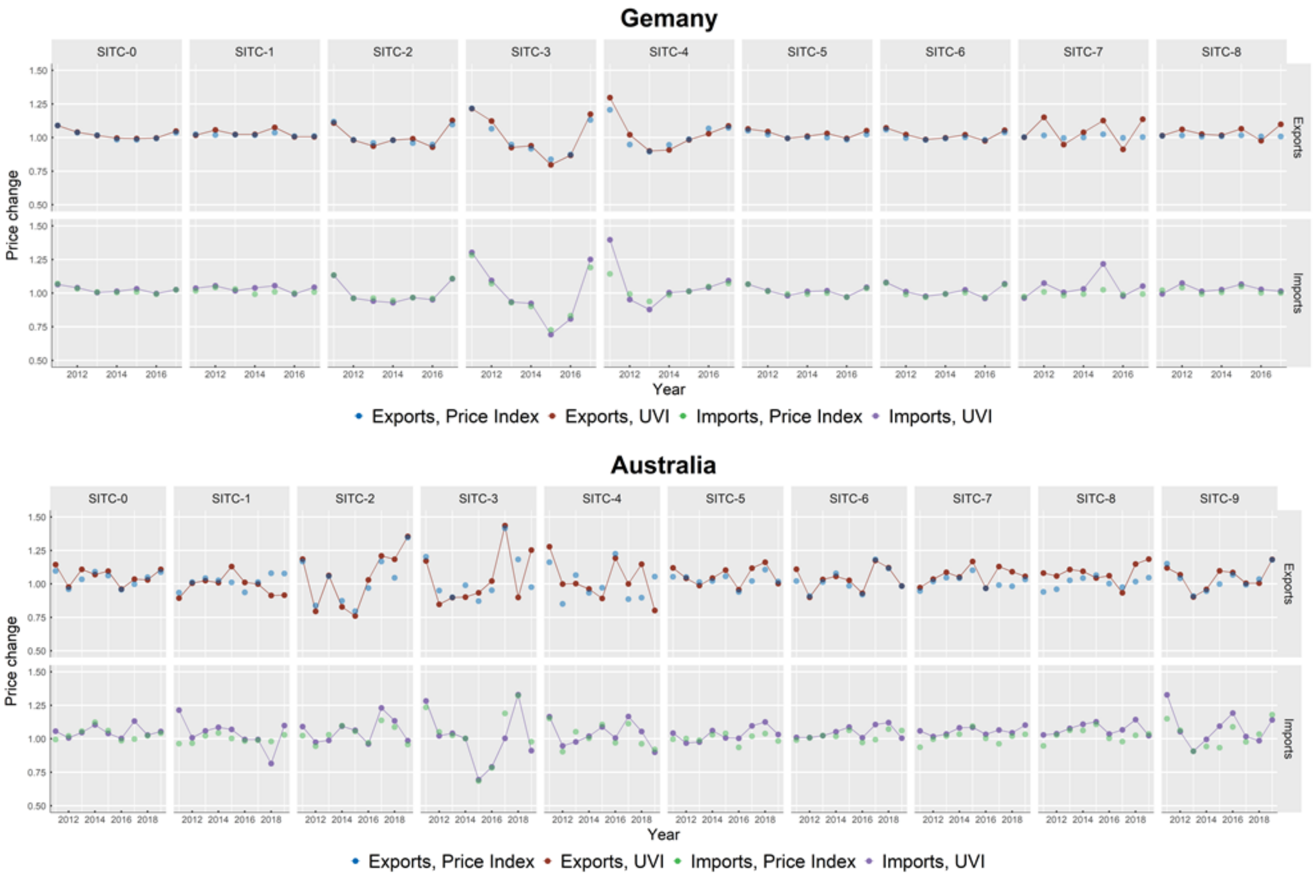
Germany, Australia and Canada have reported annual trade price indices by SITC 1-digit and they have used different methodologies for estimating trade prices and price changes.

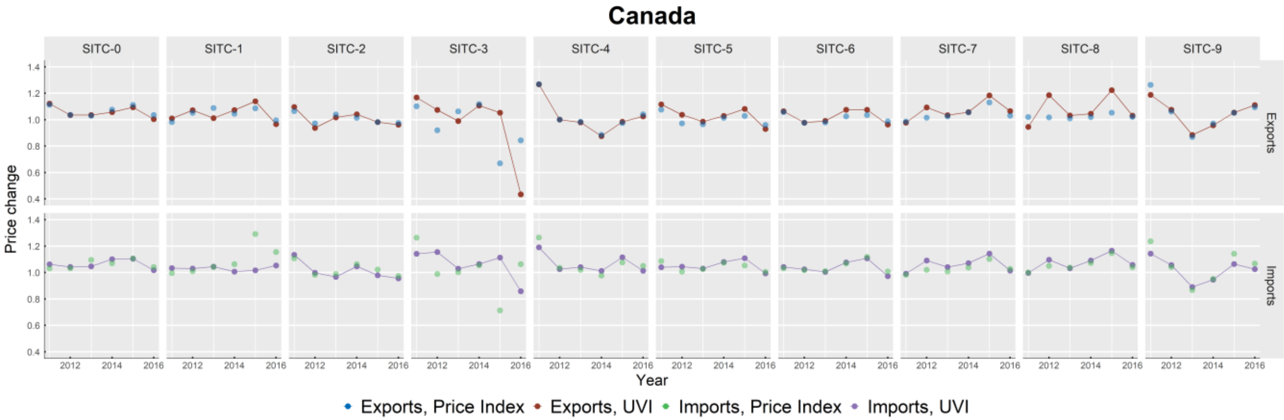
- Germany's trade prices are collected via a monthly survey of 3 000 companies for a total of 1 214 commodities for imports at C.I.F. prices and 1 196 commodities for exports at f.o.b. prices. For certain commodities traded at international commodity exchanges, such as oil, grain, non-ferrous metals and precious metals, monthly average rates observed on the market are used. Trade price indices are calculated using Laspeyres, and without quality adjustments. Data was only available until 2017.
- Australia uses quarterly surveys for selected products and measures F.O.B. prices for both exports and imports. In addition, quality changes are accounted for.[10] However, for items that are homogeneous and where quality change is minimal, e.g. basic commodities from the mining and agricultural sectors, it selectively uses average unit values as proxies for prices. Trade prices indices are annually reweighted chained Lowe price indices, which have the basket of goods fixed over a given interval of time.
- Canada only utilises customs data and follows a UVI approach to estimate import and export price indices with both Paasche and Laspeyres formulas. The current methodology has undergone a revision to potentially include a survey measure for products with quality changes. Data are only available until 2017 for SITC 1-digit aggregations.

Figure 3.2 presents the comparison between the estimated UVIs with the official statistics for Germany, Australia and Canada. Overall, the estimated UVIs are well aligned with the official statistics. However, there are a few exceptions, for example when comparing Canadian official price indices (essentially UVIs) statistics in SITC-3 Mineral fuels, lubricants and related materials with unit value indices in 2017.

[10] For detailed discussion on how to treat for quality changes, see: www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/6429.0Main%20Features102014?opendocument&tabname=Summary&prodno=6429.0&issue=2014&num=&view.

## Figure 3.2. UVI and price index at SITC 1-digit level






Note: SITC-0: Food and live animals
SITC-1: Beverages and tobacco
SITC-2: Crude materials, inedible, except fuels
SITC-3: Mineral fuels, lubricants and related materials
SITC-4: Animal and vegetable oils, fats and waxes
SITC-5: Chemicals and related products n.e.s.
SITC-6: Manufactured goods classified chiefly by material
SITC-7: Machinery and transport equipment
SITC-8: Miscellaneous manufactured articles
SITC-9: Commodities and transactions not classified elsewhere in the SITC

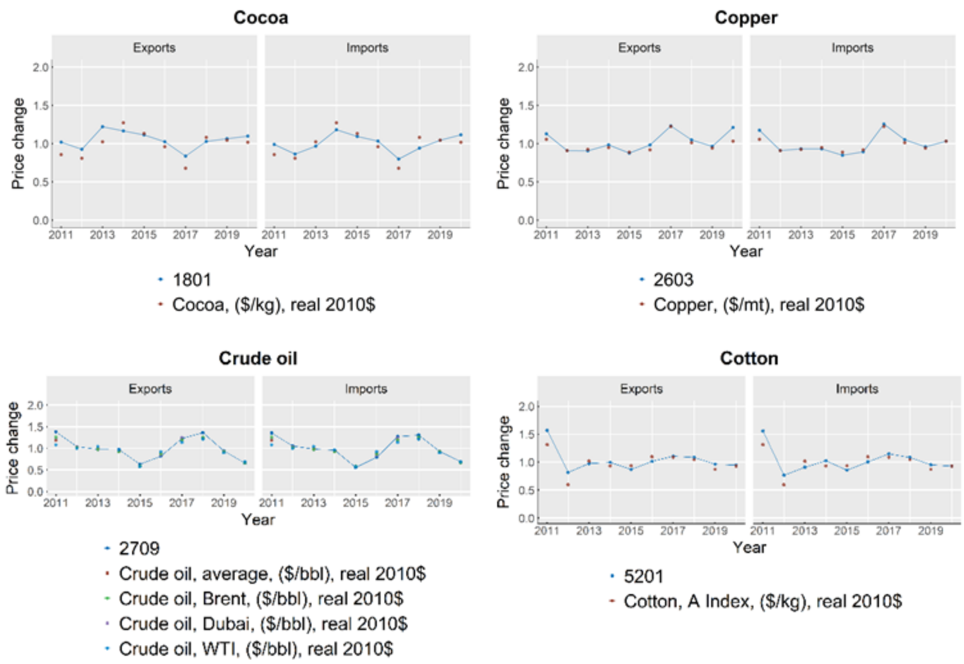
Source: Authors' calculation using UN Comtrade and data from national statistical offices.

## 3.2. Comparisons with global commodity prices

The World Bank Global Economic Monitor gathers commodity price data for a list of 81 commodities. While not entirely defined in the same manner, many of these commodities can be associated with one of the HS 4-digit UVIs (aggregated to a global level using trade values as weights). Figure 3.3 plots weighted UVIs against the reported price changes of related products in the World Bank dataset.

As for crude oil, World Bank has differentiated prices of Brent, Dubai and West Taxes Intermediates, but there is only one UVI series estimated using UN Comtrade. The results, while certainly not perfect, indicate that in particular for those products where the match between HS 4-digit category and the commodity classification is optimal, the differences between two series are often very small. The products with high price correlation (greater than 90%) are coffee, wheat, coconut oil, corns, phosphate rock, copper, silver and crude oil. Four examples are displayed below, and more comparison can be found in Annex D. A mapping between HS 4-digit products and the World Bank key commodities is presented in Annex E.

### Figure 3.3. Commodity price indices and UVIs, selected examples




Note: When a HS 4-digit code matches to multiple items in World Bank commodity database, prices changes are showed separately in the chart, such as crude oil. About 50% of countries have submitted their 2019 and 2020 trade data to UN Comtrade at the time when data are processed. Therefore, the results for these two years should be treated as provisional.
Source: World Bank and author's calculation using UN Comtrade.

## 3.3. Derived UVIs

Table 3.1 presents descriptive statistics of UVIs, expressed as the growth rate of the underlying UV – the ratio of UV at t and UV at t-1 – to assess the stability of the data at various levels of disaggregation. The medians are consistent and stable for all datasets, between 1.01 and 1.02, and the means are higher, at 1.04. See Annex F for UVI statistics for the OECD countries.

## Table 3.1. Statistics for the change in UV between t and t-1all countries, benchmarked to implicit price indices

A. Imports, using AFM method 2011-2020

| | Obs. | Average | P25th | Median | P75th | St.dev. |
|---|---|---|---|---|---|---|
| HS-4 Digit | 1,195,081 | 1.04 | 0.93 | 1.01 | 1.11 | 0.27 |
| HS-3 Digit | 216,716 | 1.04 | 0.95 | 1.02 | 1.09 | 0.18 |
| HS-2 Digit | 121,900 | 1.04 | 0.96 | 1.02 | 1.09 | 0.17 |
| CPA 2 Digit | 46,505 | 1.04 | 0.96 | 1.02 | 1.09 | 0.21 |
| SITC 1 Digit | 12,926 | 1.03 | 0.97 | 1.01 | 1.07 | 0.14 |
| ISIC4 | 31,121 | 1.03 | 0.97 | 1.02 | 1.08 | 0.15 |
| ISIC4 & End-use | 75,924 | 1.04 | 0.96 | 1.02 | 1.09 | 0.21 |

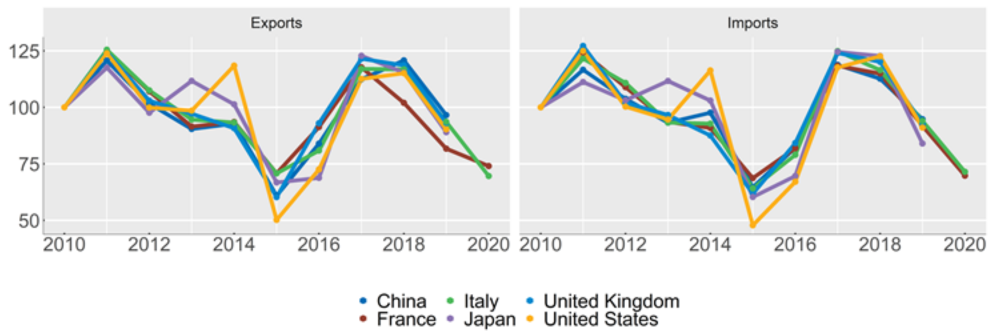
B. Exports, using AFM method 2011-2020

| | Obs. | Average | P25th | Median | P75th | St.dev. |
|---|---|---|---|---|---|---|
| HS-4 Digit | 733,370 | 1.03 | 0.93 | 1.01 | 1.10 | 0.26 |
| HS-3 Digit | 165,080 | 1.04 | 0.94 | 1.01 | 1.10 | 0.25 |
| HS-2 Digit | 97,349 | 1.04 | 0.95 | 1.01 | 1.10 | 0.23 |
| CPA 2 Digit | 39,712 | 1.05 | 0.95 | 1.02 | 1.10 | 0.54 |
| SITC 1 Digit | 12,514 | 1.04 | 0.95 | 1.02 | 1.09 | 0.28 |
| ISIC4 | 28,058 | 1.04 | 0.95 | 1.01 | 1.09 | 0.30 |
| ISIC4 & End-use | 62,257 | 1.04 | 0.94 | 1.02 | 1.11 | 0.29 |

Note: Observation count is the number of UVIs available by country, year and product category. Data are benchmarked with implicit price indices.
Source: Implicit price indices are soured from OECD, UNSD, Eurostat, and NSOs. UVIs are estimated using UN Comtrade.

One of the most volatile series during 2011-2020 is the UVIs for petroleum (see Figure 3.4). There was an over 20% increase in almost all countries in 2011. In contrast, 2015 saw a significant decrease globally and the price was only 50-70% of that in 2010. The price has recovered in 2017 and dropped again since 2018. Figure 3.4 shows that price changes are similar across selected countries.

## Figure 3.4. UVI for petroleum (CPA 19, 2010=100)



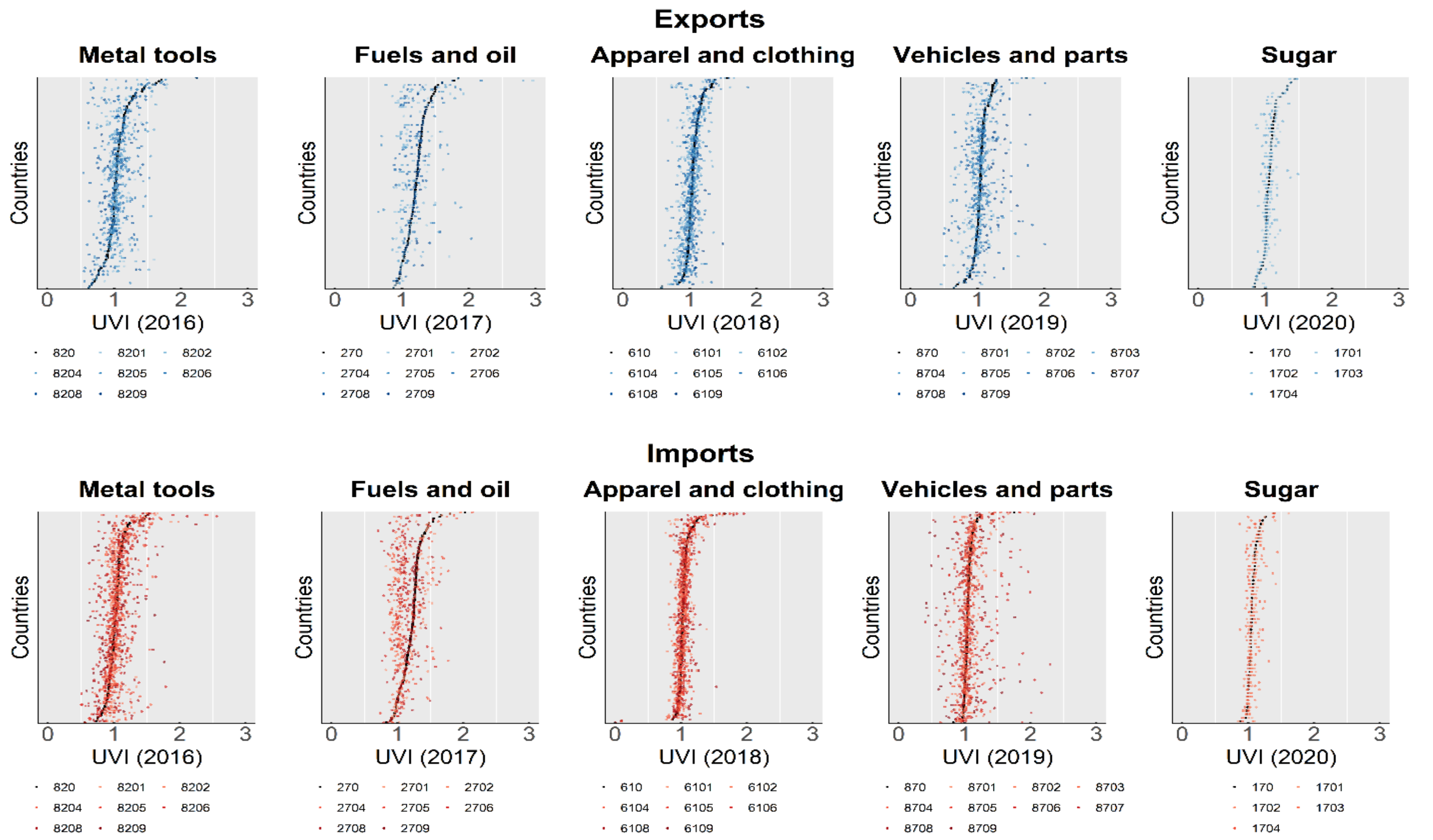

Note: Data are benchmarked with implicit price indices.
Source: Implicit price indices are soured from OECD, UNSD, Eurostat, and NSOs. UVIs are estimated using UN Comtrade.

## 3.4. UVI variations within HS 3-digit category

To examine cross-country variances, Figure 3.5 plots the benchmarked UVIs for selected years and category at the 3-digit level, and within each category the corresponding HS 4-digit products. The selected examples include metal tools (HS820) in 2016, fuels (HS270) in 2017, apparel and clothing (HS610) in 2018, vehicles and parts (HS870) in 2019 and sugar (HS170) in 2020.

Statistically, both price changes at HS 3-digit and HS 4-digit levels are estimated as the weighted average of price changes at HS 6-digit products. The black dots represent the UVIs at HS 3-digit level (sorting all countries from lowest to highest price change). The blue dots (for exports) and red dots (for imports) floating around the black dots show the UVIs for each 4-digit products that belong to an HS 3-digit category. It is evident that the variation of the UVIs at the HS 4-digit depends on the nature and heterogeneity of the products concerned – vehicles and parts (HS870) see the highest variation amongst the sub-products from 8701 to 8709, while little variations can be observed among different types of apparel and clothing (HS610).

## Figure 3.5. UVI variations across countries: HS 3- and 4-digit levels




Note: Black dots represent UVIs at HS 3-digit level (sorting from the lowest to the highest UVI for all countries) and blue and red dots represent UVIs at 4-digit. Data are benchmarked with implicit price indices. About 50% of countries have submitted their 2019 and 2020 trade data to UN Comtrade at the time when data are processed. Therefore, the results for these two years should be treated as provisional.

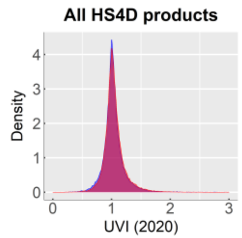
Source: Implicit price indices are soured from OECD, UNSD, Eurostat, and NSOs. UVIs are estimated by the authors using UN Comtrade.

## 3.5. Import and export unit value indices are closely mirrored for most products

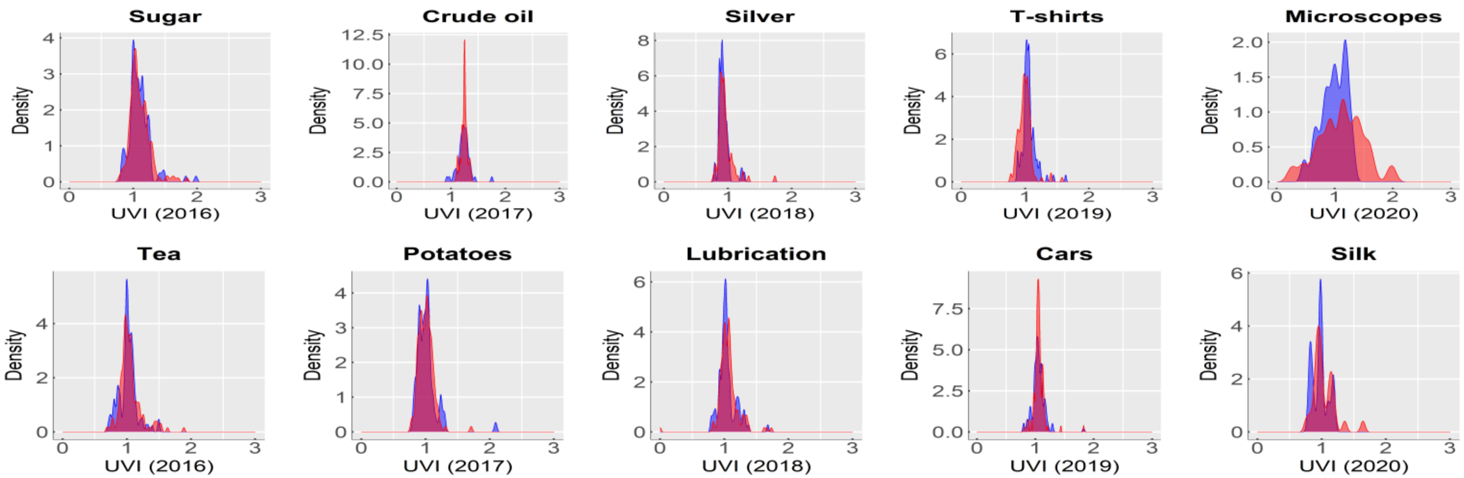
Export and import statistics represent two sides of the same trade transactions. Even if they are valued slightly differently (exports at FOB and imports at CIF), a strong correlation is expected between a product's export and import prices. Particularly as CIF-FOB margins are very stable over time (see Miao and Fortanier, 2017b) and therefore would not be expected to influence UVIs significantly. Figure 3.6 displays the distributions of both export (in blue) and import prices (in red), revealing strong overlaps. Visual analyses were preferred over statistical tests such as Chi-Square and Kolmogorov-Smirnov tests to assess the difference between the two distributions, because the number of observations in each HS 4-digit product can be small, which meant that these tests were often showed contradictory/inconclusive results.

## Figure 3.6. Overlap of UVI distributions between imports (red) and exports (blue)

A. All products for 2020




B. Selected individual products




Note: Data are benchmarked with implicit price indices. About 50% of countries have submitted their 2019 and 2020 trade data to UN Comtrade at the time when data are processed. Therefore, the results for these two years should be treated as provisional.
Source: Implicit price indices are soured from OECD, UNSD, Eurostat, and NSOs. UVIs are estimated by the authors using UN Comtrade.

The density plot for microscopes (HS 9012) shows that the range of UVIs is wider than crude oil (HS 2709) and passenger cars (HS 8703). Considering microscopes are more heterogeneous than crude oil but probably less so than passenger cars, it is normal that the range of UVIs for microscopes is wider than crude oil but why it is also wider than passenger cars? There are two plausible explanations. First, passenger cars are much more frequently traded than microscopes. Taking imports statistics as examples, there are over 240 000 entries of passenger cars in UN Comtrade from 2010 to 2020 but barely 26 000 entries of microscopes. High trading frequency helps to avoid small sample bias and leads to stable estimates. Second, passenger cars are better classified than microscopes, particularly because of their high trading frequency (for import duties and tariff measures). Under the HS heading 8703 *Motor cars and other motor vehicles principally designed for the transport of persons*, there are additional 9 HS 6-digit codes to differentiate type of passenger cars (base on size of cylinders), which are also separately reported from other type of vehicles:

- 8701 Tractors (other than tractors of heading 87.09).
- 8702 Motor vehicles for the transport of ten or more persons, including the driver.
- 8704 Motor vehicles for the transport of goods.
- 8709 Works trucks, self-propelled, not fitted with lifting or handling equipment, of the type used in factories, warehouses, dock areas or airports for short distance transport of goods; tractors of the type used on railway station platforms; parts of the fore.

Meanwhile, under the HS heading 9012 *Microscopes other than optical microscopes; diffraction apparatus*, there is no further refinement in product classification at HS 6-digit level. As a result, the large price variations (as shown in Figure 3.6B) may have lumped UVIs of different products together. If the nature of the products or the weights of the products change, UVIs of microscopes could fluctuate a lot.

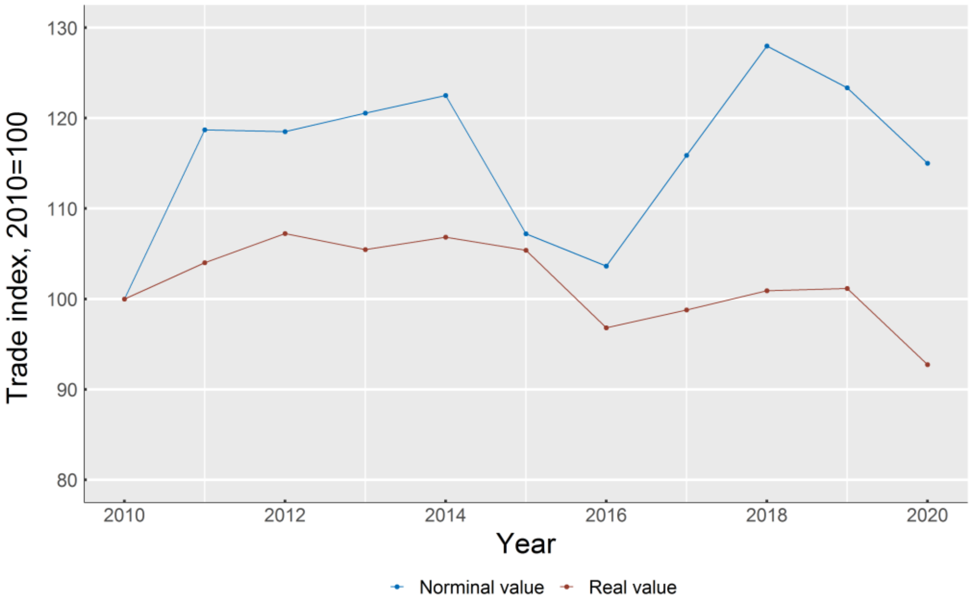
## 4. New insights from detailed merchandise unit value indices

### 4.1. Major trends in international merchandise trade are different in real terms

Major trends in international merchandise trade in nominal values are different from those in real values. Figure 4.1 shows that, as widely recognised, global merchandise trade in nominal values declines sharply in 2015, but this is mainly caused by declining prices for oil and other commodities; global merchandise trade in real values, in fact, declines only marginally once adjusted for price changes (in USD). Likewise, the rising commodity prices in 2011 and 2018 underpin that the growth in merchandise trade are chiefly driven by changes in prices.

Likely interrupted by the COVID-19 crisis, global merchandise trade declined in both nominal and real values in 2020. Trade values in 2020 were 15% higher than those in 2010. Once adjusted for prices changes, trade volumes hit the historical low in the past decade, and only represented only 92% of trade in 2010.

**Figure 4.1. Global merchandise imports (in USD), in nominal and real values, 2010-2020 (chained, 2010=100)**

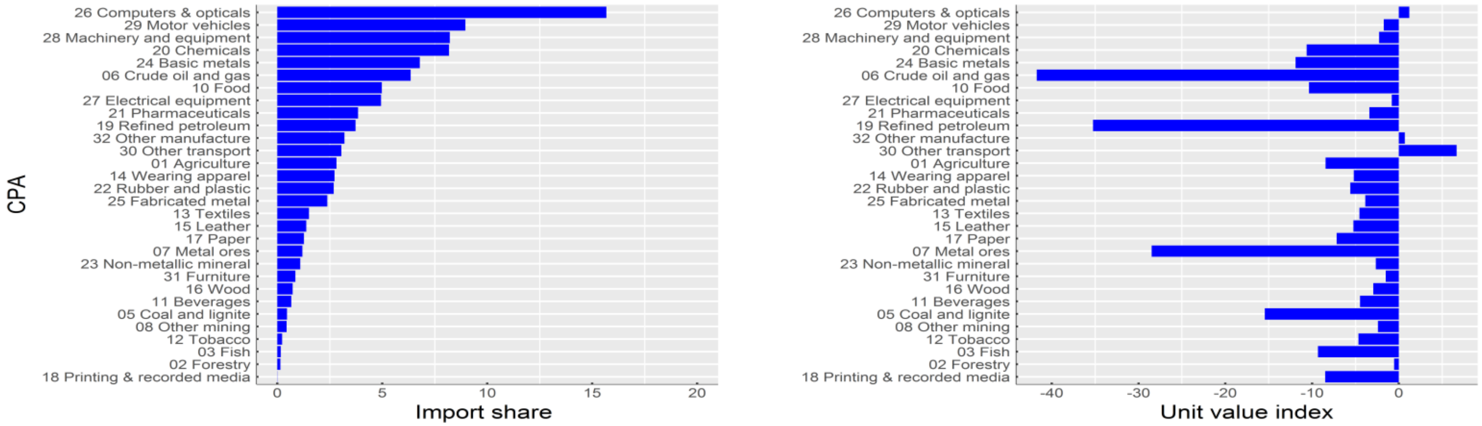



Note: Indicator is based on 98 countries for which chained price data are available for the entire period. UVIs at NCU are first transformed to UVIs in USD by applying $UVI_{USD,t} = UVI_{NCU,t}\frac{XR_{t-1}}{XR_t}$. These UVIs in USD are then used to deflate nominal trade values in USD at the CPA level for each country. These deflated trade values per country and CPI are then summed to obtain the global merchandise imports in real terms. Both the real and nominal global import values are then indexed to 2010.
Source: Authors' calculation using UN Comtrade.

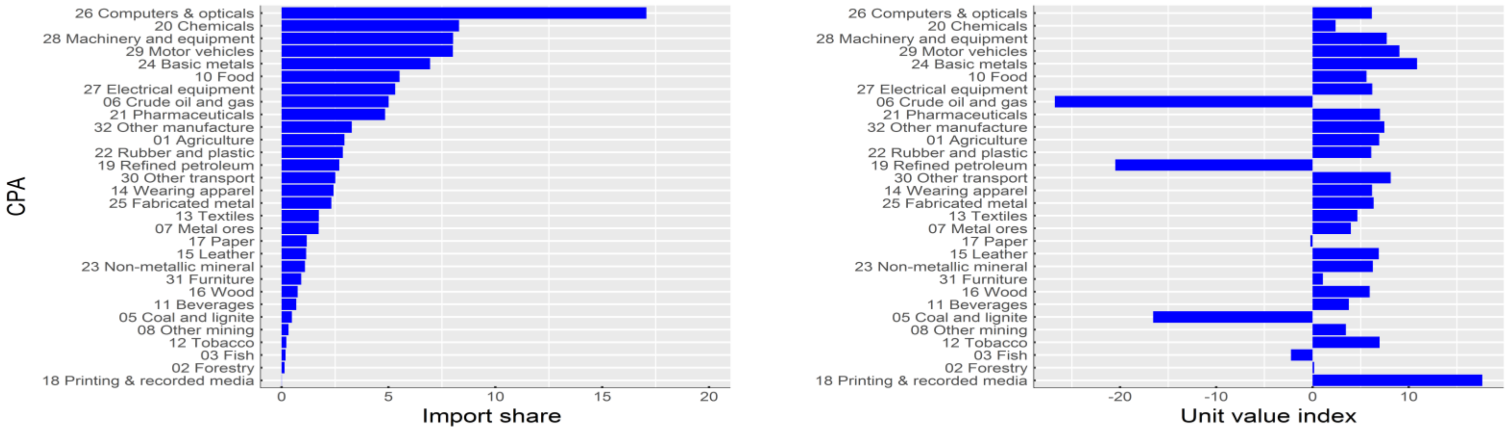
The value of a granular dataset of UVIs also lies in its ability to analyse these trends in global merchandise trade at a more detailed product level. Figure 4.2, panel A shows the UVIs in 2015 and the share in global merchandise trade by product at CPA 2-digit level. The panel on the left-hand side illustrates the relative importance of the products, showing, for example, that computers and opticals (CPA26) are the most-traded products and accounting for 17% of global merchandise trade. The panel on the right-hand side reflects UVIs (in USD), illustrating sharp declines in unit value of almost all products and, notably, falls in unit values of metal ores (CPA07), crude petroleum and natural gas (CPA06), and refined petroleum (CPA19). In fact, these declining unit values across the board in 2015 are largely due to the appreciation of the US dollar. Figure 4.2, panel B shows the same two panels for the year 2020. While the left-hand panel shows a slight reordering in terms of product shares in global merchandise trade (which can be also driven by price effects), the right-hand panel shows that only energy related goods experience drops in unit values (with *crude oil and gas* being the largest), while others products actually have become more expensive likely due to the supply shock. This further illustrates that the declining trade volume in 2020 was not merely a price effect.

## Figure 4.2. Product share in global merchandise imports and unit value indices in USD, by CPA

Panel A. 2015



Panel B. 2020



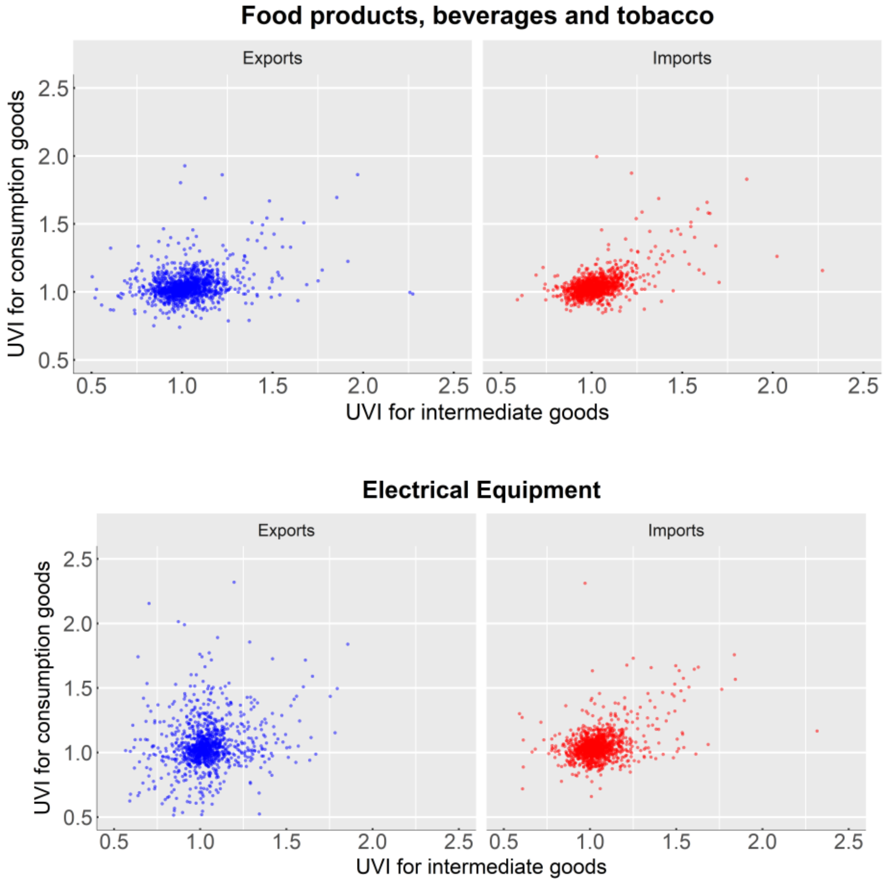

Note: Indicator is based on 98 countries for which chained price data are available for the entire period.
Source: Authors' calculation using UN Comtrade.

## 4.2. UVIs of products for intermediate and final use

In developing various degrees of disaggregation for UVIs, a breakdown by industry (ISIC rev. 4) *and* end-use category (intermediate, consumption and capital goods) is included, in particular, to support discussions towards the developments of international supply and use and input-output tables in constant prices (see Miao and Fortanier, 2017a). A weak correlation between UVIs of product for intermediate and final use within the same industry points to the necessity of differentiating UVIs by end-use category.

The UVI data show an overall rather low correlation between intermediate and final use products (at 0.12). This is illustrated in Figure 4.4 with two examples for food, beverages and tobacco, and electrical equipment. Products of food, beverages and tobacco industry may be more homogeneous than those of the electrical equipment: the UVIs of processed coffee beans for final consumption is positively correlated with that of unprocessed/unroasted coffee beans for intermediate use (0.19); while the UVIs of electrical equipment for industrial and final use may well be different (with a barely positive correlation of 0.02).

### Figure 4.3. UVI correlation between intermediate and final goods, 2011-2020




Note: Trade flows are divided into economic activities based on the Revision 4 of ISIC and into nine end-use categories including capital goods, intermediate goods and household consumption, adopted same conversion table as in OECD Bilateral Trade Database by Industry and End-use (BTDIxE).
Source: Authors' calculation using UN Comtrade.

## 5. Conclusions

Any meaningful analysis of structural changes in international trade requires information on value and volume changes, and consequently detailed product-level information on unit value indices (UVIs). However, statistical information has remained scarce, mostly because of the conceptual challenges and demand on resources that gathering detailed statistics require. Customs data that include information on values and quantities are an important potential source, even if the UVIs that can be derived from these data are often considered as imperfect measures of price changes. A careful data cleaning process is also required, as errors, confidentiality and other factors listed in the introduction may generate significant noise.

This paper introduces a three-stage approach for outlier removal, in order to develop a robust dataset of UVIs. This approach excludes first unit values at the HS 6-digit level that significantly depart from the cross-country median within HS 4-digit groups; it subsequently removes unrealistic year-on-year unit value changes, and finally removes unit value changes that are significantly different from those of other countries trading the products in the same stratum. UVIs are developed by explicitly incorporating unit value changes across different quantity units within the same product group, without resorting to any artificial conversion factors. Furthermore, significant trade flows (i.e. more than 10% of total trade value in a given HS 4-digit-quantity code stratum) are checked manually and preserved if deemed correct. In addition, the cut-off boundaries for the second and third stages of outlier detection follow a dual-selection approach using both USD and national currencies, where data are considered as outliers only if it is outside the range in both. In the future, there is a possibility of including normalised outlier detection by introducing a broad inflation normalising factor.

The paper makes three distinctive contributions to this literature. First, it fully utilises trade data recorded in all quantity units, not just in kilogrammes. The quantity codes serve as a stratification, so that all possible records can be used for UVI estimation instead of abandoning them or imputing them with mirrored flows. Second, it highlights the importance of having a “suitable” stratification for outlier detection that depends on data availability. For example, if the data become available at the 8-digit or at 10-digit, the stratification could be fine-tuned accordingly. Finally the paper sheds light on development in global merchandise trade in the aftermath of the COVID-19 crisis. Global merchandise trade declined in both nominal and real values in 2020. Trade values in 2020 were 15% higher than those in 2010. Once adjusted for prices changes, trade volumes hit the historical low in the past decade, and represented only 92% of trade in 2010.

This paper has presented country-product specific UVIs using merchandise trade data and proved that the results are plausible, even though UVIs, by definition, cannot respond to some of the conceptual issues to measure price changes. The aggregated UVIs matched well with the overall implicit price indices as derived from countries’ official national accounts, and indeed, proved to be good proxies. For the selected group of countries where data are available, the UVIs also closely resembled official price indices at the SITC 1-digit level. Comparison with global commodity price indices (for raw materials and agricultural products) has also pointed at a strong accord.

However, the UVIs calculated cover over 70% of trade for frequently traded countries, and much less for the least frequently traded countries, which directly points to the need for better reporting and better recording international merchandise trade statistics, i.e. through improved classification for products and providing tailored trainings for custom officers.

This analysis opens a canopy of possibilities for statistical and economical research in the future with merchandise trade data:

- The new products (such as 3D printers and drones) can be also used for calculating UVIs in the future if one relaxes the "fixed basket of goods" approach.
- One could expect that in general high-income countries would sell better-quality products at higher prices. If trade data are available at 8- or 10-digit level (providing a sufficient number of observations in each stratum), UVIs can be estimated by country, product and trading partner.
- Firm-level trade transactions, as opposed to country aggregates, have been used for the purpose of detecting illicit trade flows (for tax avoidance) – exports or imports transactions at much higher or lower unit values can be detected using the same methods.
- The emphasis of this paper has been on deriving robust measures of UVIs, but the focus can be shift to the unit values, which point to some interesting questions for further investigation: why can some countries sell relatively homogeneous products within the same HS classification, such as coffee, at higher prices but others cannot?
- How does a price shock in one country propagates through the GVC to another country, potentially causing either an inflation in the final country where the product is consumed, or a reduction in producing country competitiveness?

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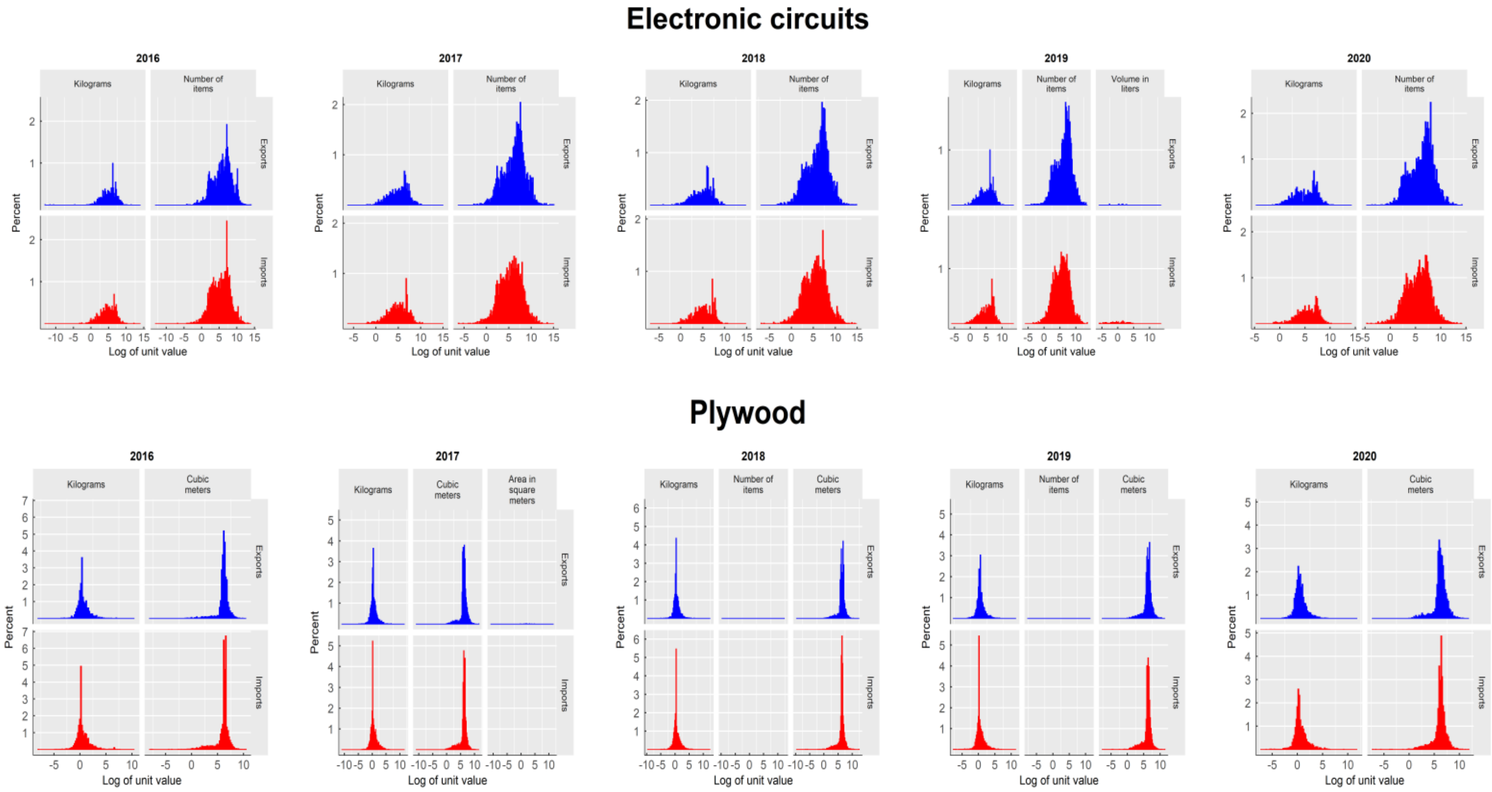
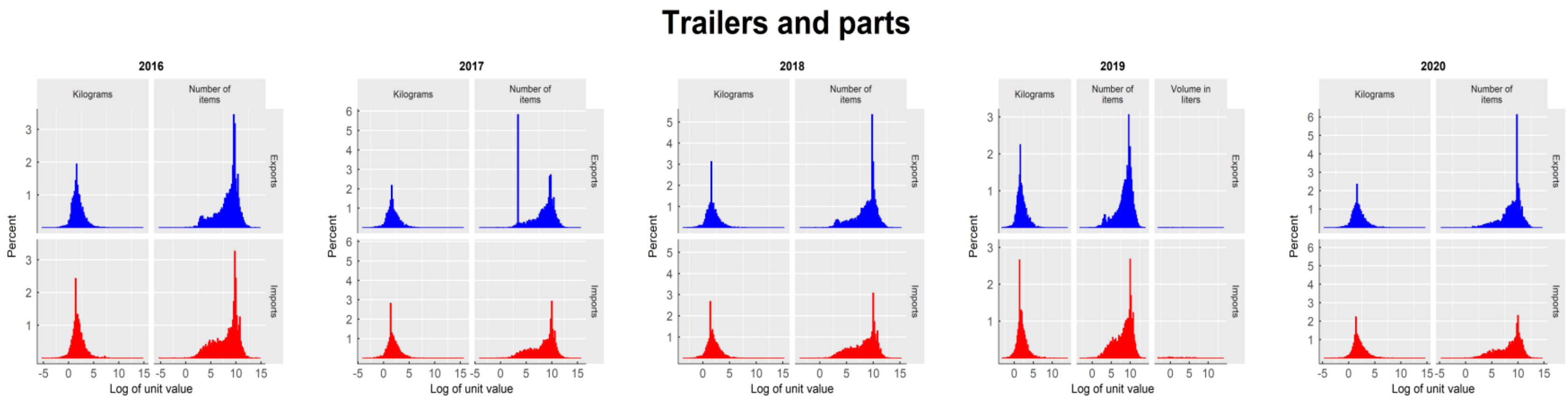
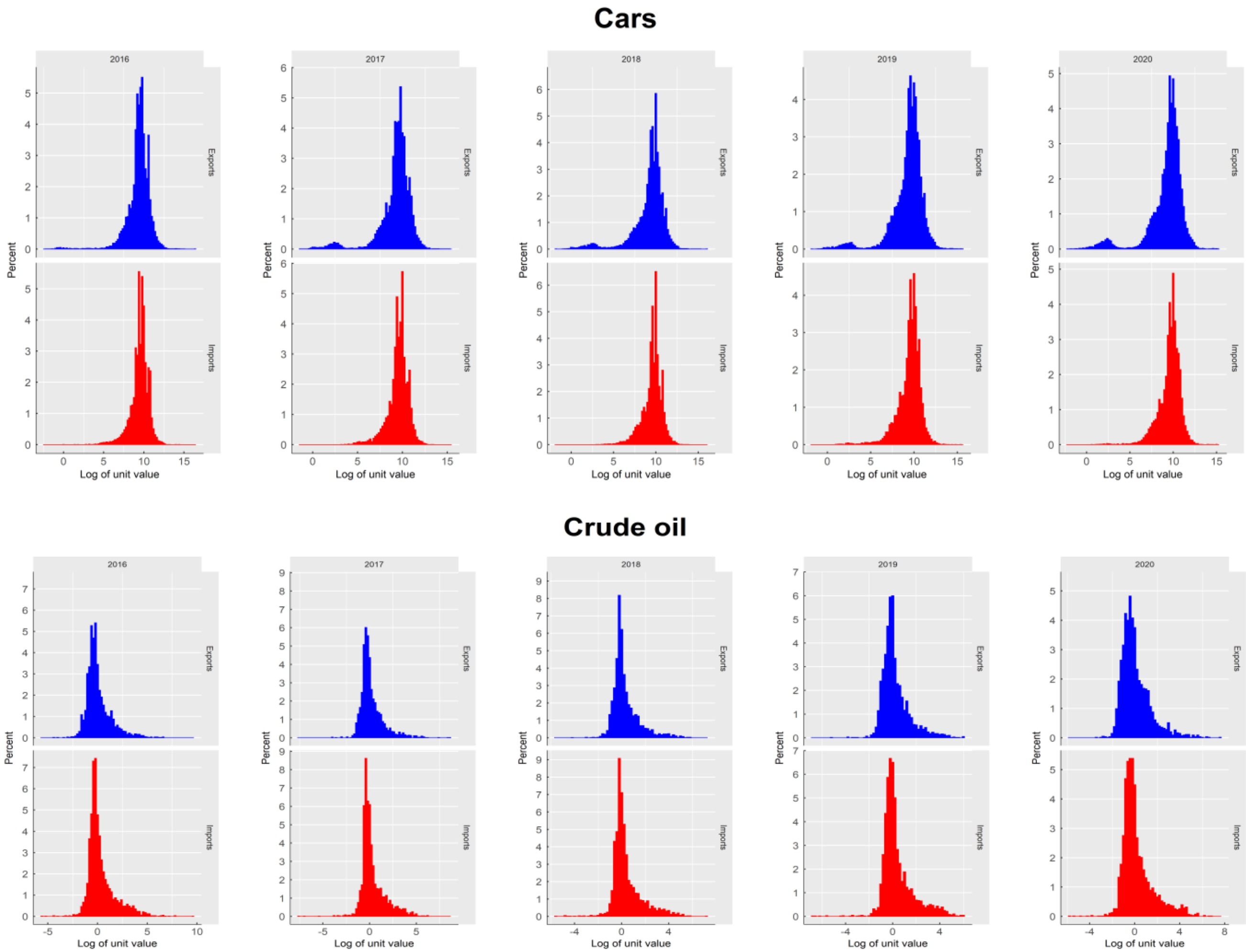
# Annex A. Unit value distributions

## Figure A.1. Distribution of log unit values split by quantity and year for selected products in selected years

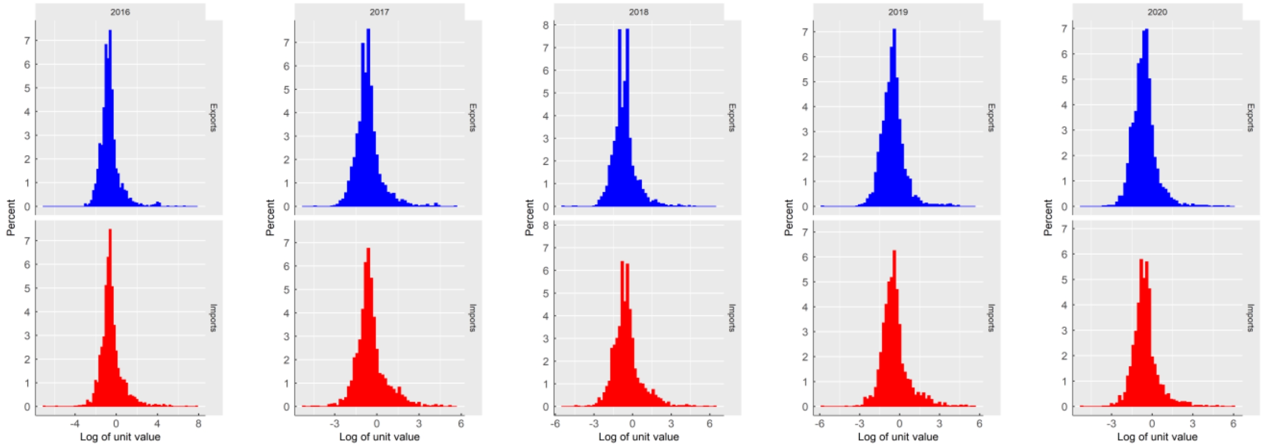



Trailers and parts
2016
2017
2018
2019
2020
Kilograms
Number of items
Volume in liters
Exports
Imports
Percent
Log of unit value

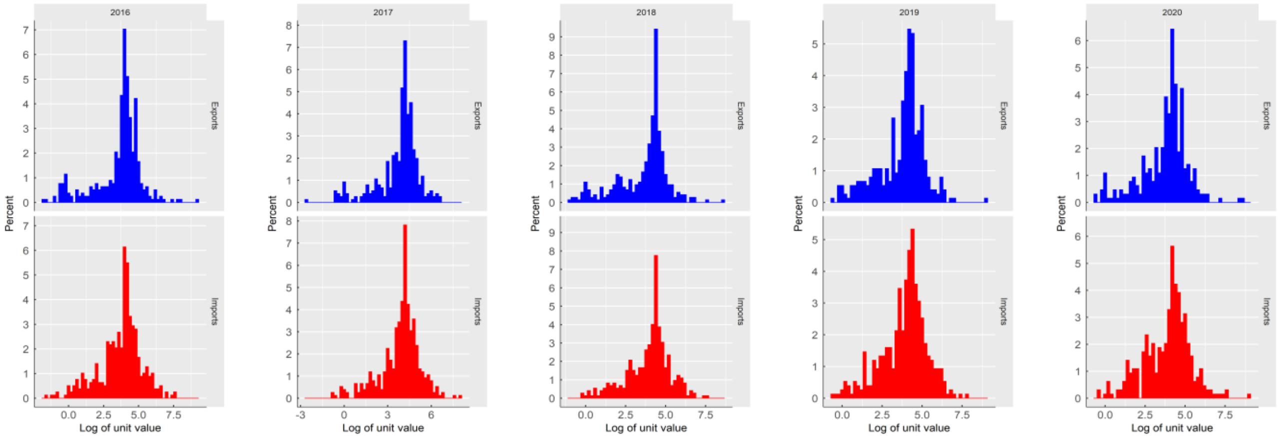
## Figure A.2. Distribution of log unit values split by year for selected products



**Potatoes**




**Silk**




Source: Authors' calculation using UN Comtrade.

# Annex B. Frequently trading countries

## Table B.1. Frequently trading countries and the share of observations remaining after each outlier detection phase, Imports, 2010-2020

| Country | Average # of observations | Average share of observations for which UV are available | | | |
|---|---|---|---|---|---|
| | | Total* | After outlier detection phase 1** | After outlier detection phase 2** | After outlier detection phase 3** |
| ARE | 807,566 | 86% | 88% | 69% | 65% |
| AUS | 695,497 | 94% | 89% | 81% | 67% |
| AUT | 905,774 | 85% | 92% | 85% | 82% |
| BEL | 853,503 | 91% | 87% | 80% | 71% |
| BGR | 493,547 | 91% | 89% | 82% | 74% |
| BRA | 586,748 | 96% | 83% | 77% | 73% |
| CAN | 1,087,059 | 74% | 91% | 84% | 79% |
| CHE | 1,003,081 | 97% | 81% | 73% | 70% |
| CHL | 591,049 | 99% | 81% | 71% | 64% |
| CHN | 911,069 | 93% | 86% | 77% | 75% |
| CZE | 829,216 | 93% | 89% | 83% | 77% |
| DEU | 1,265,841 | 83% | 90% | 83% | 77% |
| DNK | 767,578 | 91% | 90% | 84% | 74% |
| ESP | 972,030 | 93% | 87% | 80% | 71% |
| EST | 516,501 | 86% | 88% | 80% | 73% |
| FIN | 639,027 | 87% | 87% | 79% | 73% |
| FRA | 1,227,735 | 90% | 90% | 85% | 78% |
| GBR | 978,980 | 91% | 88% | 82% | 76% |
| GRC | 522,550 | 95% | 89% | 80% | 73% |
| HKG | 489,115 | 92% | 82% | 75% | 73% |
| HRV | 542,262 | 91% | 89% | 76% | 64% |
| HUN | 594,694 | 83% | 89% | 82% | 76% |
| IDN | 599,391 | 86% | 91% | 83% | 74% |
| IND | 768,459 | 96% | 84% | 78% | 73% |
| IRL | 520,519 | 87% | 82% | 76% | 70% |
| ISR | 494,805 | 65% | 93% | 79% | 69% |
| ITA | 991,402 | 94% | 90% | 86% | 81% |
| JPN | 584,951 | 89% | 89% | 85% | 81% |
| KOR | 790,965 | 80% | 91% | 85% | 83% |
| LTU | 530,122 | 93% | 90% | 84% | 74% |
| MEX | 585,095 | 52% | 86% | 73% | 68% |
| MYS | 587,592 | 99% | 86% | 77% | 67% |
| NLD | 1,323,078 | 88% | 90% | 80% | 71% |
| NOR | 773,309 | 98% | 85% | 80% | 74% |
| NZL | 616,230 | 92% | 90% | 83% | 74% |

| | | | | | |
|---|---|---|---|---|---|
| POL | 855,485 | 92% | 90% | 86% | 81% |
| PRT | 535,596 | 93% | 94% | 87% | 80% |
| ROM | 700,768 | 90% | 89% | 84% | 77% |
| RUS | 816,551 | 97% | 80% | 74% | 70% |
| SGP | 817,175 | 87% | 87% | 72% | 67% |
| SRB | 560,432 | 81% | 92% | 87% | 83% |
| SVK | 594,124 | 92% | 87% | 81% | 73% |
| SVN | 626,607 | 95% | 91% | 86% | 80% |
| SWE | 728,775 | 90% | 91% | 87% | 82% |
| THA | 805,788 | 92% | 87% | 80% | 75% |
| TUR | 707,413 | 86% | 91% | 85% | 80% |
| UKR | 567,393 | 94% | 85% | 72% | 68% |
| USA | 1,101,742 | 89% | 84% | 77% | 73% |
| VNM | 500,380 | 68% | 96% | 81% | 77% |
| ZAF | 871,972 | 92% | 84% | 73% | 67% |

Note: Percentages are taken with respect to the number of observations available that have a reported quantity unit and amount.
* The denominator used in calculating shares is the total trade flow. For example, 89% of trade values have quantity information where unit value can be calculated.
** The denominator used based on the trade flows where unit value is available. In other words, it reflects only trade flows where quantities and trade values are available at the same time.
Source: Authors’ calculation using UN Comtrade.

# Annex C. Comtrade quantity codes and their frequency in trade

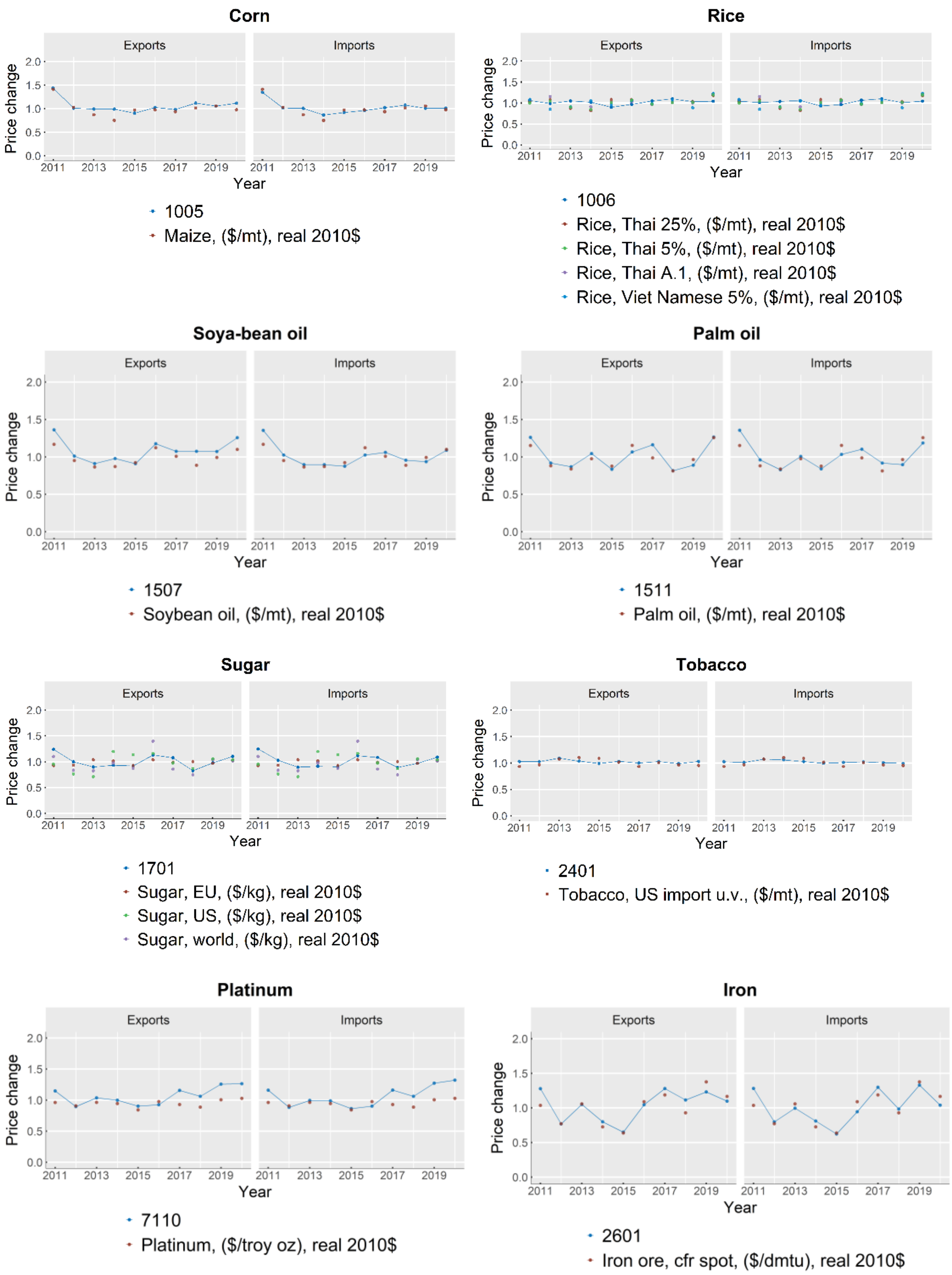
## Table C.1. Comtrade quantity unit codes and their frequency before and after removal of outliers (all three stages), 2011-2020

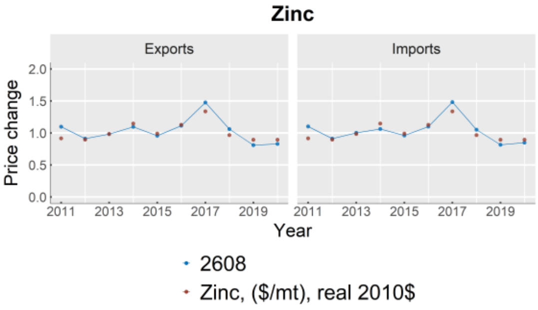
| Quantity Code | Description | Export Frequency | | Import Frequency | |
|---|---|---|---|---|---|
| | | Original | After outlier detection | Original | After outlier detection |
| 1 | No quantity | 11,055,758 | 0 | 11,053,361 | 0 |
| 2 | Area in square meters | 753,689 | 175,327 | 753,517 | 175,261 |
| 3 | Electrical energy in thousands of kilowatt-hours | 4,262 | 1,505 | 4,262 | 1,504 |
| 4 | Length in meters | 25,895 | 3,141 | 25,893 | 3,144 |
| 5 | Number of items | 20,320,374 | 5,163,615 | 20,314,335 | 5,161,735 |
| 6 | Number of pairs | 866,058 | 216,437 | 865,857 | 216,360 |
| 7 | Volume in litres | 855,248 | 238,863 | 855,126 | 238,836 |
| 8 | Weight in kilograms | 70,264,546 | 20,305,264 | 70,250,295 | 20,300,649 |
| 9 | Thousand of items | 8,873 | 1,795 | 8,872 | 1,796 |
| 10 | Number of packages | 17,613 | 5,382 | 17,613 | 5,382 |
| 11 | Dozen of items | 4,537 | 845 | 4,537 | 846 |
| 12 | Volume in cubic meters | 306,915 | 76,893 | 306,807 | 76,892 |
| 13 | Weight in carats | 42,699 | 7,099 | 42,694 | 7,103 |

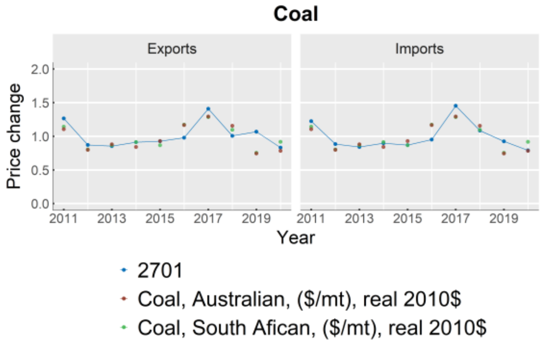
Note: Frequencies are calculated based on countries reporting at 6-digit product level, by partner, year, and quantity code; Trades without quantity (No quantity) are never kept since no unit values can be calculated.
Source*:* Authors' calculation using UN Comtrade.

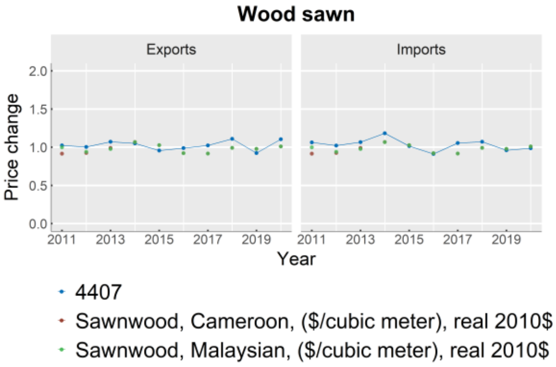
# Annex D. Global commodity prices and UVIs

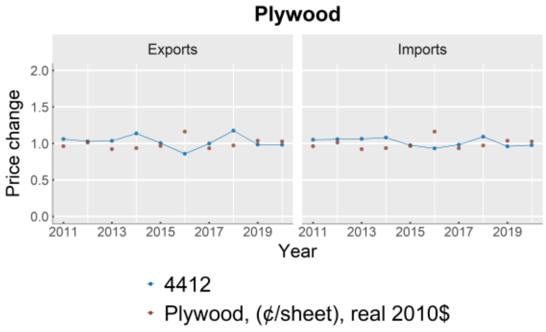
## Figure D.1. Commodity price index and UVI, selected examples








Note: When a HS 4-digit matches to multiple items in World Bank commodity database, prices changes are showed separately in the chart, as in wood sawn.
Source: World Bank and author's calculation using UN Comtrade.

# Annex E. World commodity correspondence to HS-4 digit product

## Table E.1. Matching between World Bank's reported commodities and HS-4 digit products

| Commodity | HS-4 digit | HS Description |
|---|---|---|
| Aluminium | 2510 | Natural calcium phosphates, natural aluminium calcium phosphates and phosphatic chalk |
| Banana, Europe | 0803 | Bananas, including plantains, fresh or dried |
| Banana, US | 0803 | Bananas, including plantains, fresh or dried |
| Barley | 1003 | Barley |
| Coal, Australian | 2701 | Coal; briquettes, ovoids and similar solid fuels manufactured from coal |
| Coal, South African | 2701 | Coal; briquettes, ovoids and similar solid fuels manufactured from coal |
| Cocoa | 1801 | Cocoa beans, whole or broken, raw or roasted |
| Coconut oil | 1513 | Coconut (copra), palm kernel or babassu oil and fractions thereof, whether or not refined, but not chemically modified |
| Coffee, Arabica | 0901 | Coffee, whether or not roasted or decaffeinated; coffee husks and skins; coffee substitutes containing coffee in any proportion |
| Coffee, Robusta | 0901 | Coffee, whether or not roasted or decaffeinated; coffee husks and skins; coffee substitutes containing coffee in any proportion |
| Copper | 2603 | Copper ores and concentrates |
| Cotton, A Index | 5201 | Cotton not carded or combed |
| Crude oil, average | 2709 | Petroleum oils and oils obtained from bituminous minerals, crude |
| Crude oil, Brent | 2709 | Petroleum oils and oils obtained from bituminous minerals, crude |
| Crude oil, Dubai | 2709 | Petroleum oils and oils obtained from bituminous minerals, crude |
| Crude oil, WTI | 2709 | Petroleum oils and oils obtained from bituminous minerals, crude |
| DAP | 2510 | Natural calcium phosphates, natural aluminium calcium phosphates and phosphatic chalk |
| Gold | 7108 | Gold (including gold plated with platinum) unwrought or in semi-manufactured forms, or in powder form |
| Groundnut oil | 1508 | Ground-nut oil and its fractions, whether or not refined, but not chemically modified |
| Iron ore, cfr spot | 2601 | Iron ores and concentrates, including roasted iron pyrites |
| Lead | 2607 | Lead ores and concentrates |
| Logs, Cameroon | 4401 | Fuel wood, in logs, in billets, in twigs, in faggots or in similar forms; wood in chips or particles; sawdust and wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms |
| Logs, Malaysian | 4401 | Fuel wood, in logs, in billets, in twigs, in faggots or in similar forms; wood in chips or particles; sawdust and wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms |
| Maize | 1005 | Maize (corn) |
| Meat, chicken | 0207 | Meat and edible offal, of the poultry of heading 01.05, fresh, chilled or frozen |
| Natural gas, Europe | 2705 | Coal gas, water gas, producer gas and similar gases, other than petroleum gases and other gaseous hydrocarbons |
| Natural gas, US | 2705 | Coal gas, water gas, producer gas and similar gases, other than petroleum gases and other gaseous hydrocarbons |
| Nickel | 2604 | Nickel ores and concentrates |
| Orange | 2824 | Lead oxides; red lead and orange lead |
| Palm oil | 1511 | Palm oil and its fractions, whether or not refined, but not chemically modified |

| | | |
|---|---|---|
| Phosphate rock | 2510 | Natural calcium phosphates, natural aluminium calcium phosphates and phosphatic chalk |
| Platinum | 7110 | Platinum, unwrought or in semi-manufactured forms, or in powder form |
| Plywood | 4412 | Plywood, veneered panels and similar laminated wood |
| Rice, Thai 25% | 1006 | Rice |
| Rice, Thai 5% | 1006 | Rice |
| Rice, Thai A.1 | 1006 | Rice |
| Rice, Vietnamese 5% | 1006 | Rice |
| Rubber, SGP/MYS | 4001 | Natural rubber, balata, gutta-percha, guayule, chicle and similar natural gums, in primary forms or in plates, sheets or strip |
| Rubber, TSR20 | 4001 | Natural rubber, balata, gutta-percha, guayule, chicle and similar natural gums, in primary forms or in plates, sheets or strip |
| Sawnwood, Cameroon | 4407 | Wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm |
| Sawnwood, Malaysian | 4407 | Wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm |
| Silver | 7106 | Silver (including silver plated with gold or platinum), unwrought or in semi-manufactured forms, or in powder form |
| Sorghum | 1007 | Grain sorghum |
| Soybean meal | 1201 | Soya beans, whether or not broken |
| Soybean oil | 1507 | Soya-bean oil and its fractions, whether or not refined, but not chemically modified |
| Soybeans | 1201 | Soya beans, whether or not broken |
| Sugar, EU | 1701 | Cane or beet sugar and chemically pure sucrose, in solid form |
| Sugar, US | 1701 | Cane or beet sugar and chemically pure sucrose, in solid form |
| Sugar, world | 1701 | Cane or beet sugar and chemically pure sucrose, in solid form |
| Tea, avg 3 auctions | 0902 | Tea, whether or not flavoured |
| Tea, Colombo | 0902 | Tea, whether or not flavoured |
| Tea, Kolkata | 0902 | Tea, whether or not flavoured |
| Tea, Mombasa | 0902 | Tea, whether or not flavoured |
| Tin | 2609 | Tin ores and concentrates |
| Tobacco, US import u.v. | 2401 | Unmanufactured tobacco; tobacco refuse |
| TSP | 2510 | Natural calcium phosphates, natural aluminium calcium phosphates and phosphatic chalk |
| Urea | 2847 | Hydrogen peroxide, whether or not solidified with urea |
| Wheat, US HRW | 1001 | Wheat and meslin |
| Wheat, US SRW | 1001 | Wheat and meslin |
| Zinc | 2608 | Zinc ores and concentrates |

Note: The matching represents the closest possible matching found by the authors.
Source: World bank commodity list and UN Comtrade product classification.

# Annex F. Unit Value Index summary statistics for OECD countries

## Table F.1. Export UVI summary statistics on CPA level for OECD countries, 2011-2020

| Country | Obs. | Average | Minimum | P25th | Median | P75th | Maximum | St. dev. |
|---|---|---|---|---|---|---|---|---|
| AUS | 324 | 1.08 | 0.41 | 0.99 | 1.05 | 1.12 | 4.25 | 0.29 |
| AUT | 372 | 1.03 | 0.51 | 0.99 | 1.02 | 1.06 | 1.90 | 0.14 |
| BEL | 383 | 1.03 | 0.36 | 0.98 | 1.02 | 1.07 | 3.15 | 0.17 |
| CAN | 336 | 1.05 | 0.35 | 0.98 | 1.03 | 1.09 | 2.50 | 0.18 |
| CHE | 370 | 1.01 | 0.28 | 0.96 | 1.01 | 1.04 | 2.23 | 0.16 |
| CHL | 328 | 1.05 | 0.30 | 0.99 | 1.05 | 1.11 | 3.69 | 0.20 |
| COL | 305 | 1.07 | 0.47 | 0.99 | 1.05 | 1.13 | 1.80 | 0.15 |
| CRI | 275 | 1.02 | 0.32 | 0.96 | 1.02 | 1.09 | 2.06 | 0.16 |
| CZE | 378 | 1.03 | 0.45 | 0.98 | 1.03 | 1.07 | 1.89 | 0.14 |
| DEU | 394 | 1.02 | 0.33 | 0.98 | 1.01 | 1.05 | 2.21 | 0.14 |
| DNK | 360 | 1.02 | 0.31 | 0.98 | 1.02 | 1.06 | 1.93 | 0.15 |
| ESP | 392 | 1.03 | 0.65 | 0.98 | 1.02 | 1.06 | 3.75 | 0.20 |
| EST | 340 | 1.02 | 0.29 | 0.97 | 1.02 | 1.06 | 2.50 | 0.17 |
| FIN | 338 | 1.04 | 0.40 | 0.98 | 1.02 | 1.07 | 2.43 | 0.20 |
| FRA | 385 | 1.03 | 0.42 | 0.98 | 1.02 | 1.06 | 2.26 | 0.17 |
| GBR | 358 | 1.13 | 0.58 | 0.99 | 1.04 | 1.09 | 30.66 | 1.57 |
| GRC | 373 | 1.03 | 0.41 | 0.97 | 1.01 | 1.06 | 2.24 | 0.17 |
| HUN | 365 | 1.03 | 0.27 | 0.99 | 1.03 | 1.07 | 1.55 | 0.12 |
| IRL | 342 | 1.03 | 0.32 | 0.97 | 1.01 | 1.06 | 2.30 | 0.20 |
| ISL | 280 | 1.06 | 0.21 | 0.93 | 1.02 | 1.13 | 3.93 | 0.32 |
| ISR | 295 | 1.04 | 0.37 | 0.94 | 1.01 | 1.12 | 2.26 | 0.20 |
| ITA | 384 | 1.03 | 0.62 | 0.99 | 1.02 | 1.06 | 2.38 | 0.15 |
| JPN | 330 | 1.04 | 0.51 | 0.98 | 1.03 | 1.09 | 2.16 | 0.16 |
| KOR | 321 | 1.02 | 0.26 | 0.96 | 1.01 | 1.06 | 3.46 | 0.23 |
| LTU | 355 | 1.04 | 0.58 | 0.99 | 1.02 | 1.07 | 2.14 | 0.14 |
| LUX | 315 | 1.01 | 0.28 | 0.97 | 1.01 | 1.05 | 2.33 | 0.17 |
| LVA | 341 | 1.02 | 0.29 | 0.97 | 1.01 | 1.05 | 2.30 | 0.16 |
| MEX | 310 | 1.07 | 0.36 | 0.99 | 1.05 | 1.13 | 2.51 | 0.20 |
| NLD | 375 | 1.02 | 0.24 | 0.98 | 1.02 | 1.07 | 1.99 | 0.15 |
| NOR | 351 | 1.04 | 0.34 | 0.98 | 1.04 | 1.08 | 1.85 | 0.15 |
| NZL | 298 | 1.03 | 0.35 | 0.96 | 1.02 | 1.08 | 1.65 | 0.15 |
| POL | 380 | 1.03 | 0.31 | 0.99 | 1.02 | 1.06 | 2.25 | 0.15 |
| PRT | 368 | 1.03 | 0.42 | 0.98 | 1.01 | 1.06 | 2.60 | 0.17 |
| SVK | 360 | 1.01 | 0.23 | 0.97 | 1.01 | 1.05 | 3.28 | 0.20 |
| SVN | 362 | 1.03 | 0.41 | 0.98 | 1.02 | 1.05 | 3.43 | 0.23 |
| SWE | 354 | 1.03 | 0.30 | 0.98 | 1.03 | 1.07 | 2.64 | 0.16 |
| TUR | 327 | 1.15 | 0.29 | 1.07 | 1.13 | 1.23 | 2.16 | 0.20 |
| USA | 320 | 1.33 | 0.52 | 0.99 | 1.02 | 1.06 | 93.73 | 5.18 |

Source: Authors' calculation using UN Comtrade.

## Table F.2. Import UVI summary statistics on CPA level for OECD countries, 2011-2020

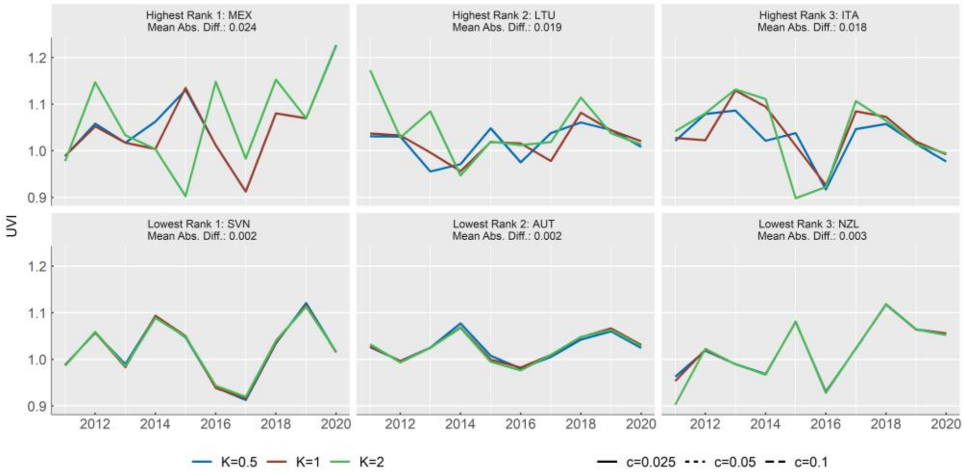
| Country | Obs. | Average | Minimum | P25th | Median | P75th | Maximum | St. dev |
|---|---|---|---|---|---|---|---|---|
| AUS | 333 | 1.06 | 0.40 | 1.00 | 1.05 | 1.11 | 1.96 | 0.16 |
| AUT | 386 | 1.03 | 0.40 | 0.98 | 1.02 | 1.06 | 1.77 | 0.15 |
| BEL | 394 | 1.03 | 0.49 | 0.98 | 1.02 | 1.07 | 2.01 | 0.14 |
| CAN | 353 | 1.05 | 0.47 | 1.00 | 1.04 | 1.09 | 1.73 | 0.12 |
| CHE | 387 | 1.01 | 0.30 | 0.96 | 1.01 | 1.05 | 2.29 | 0.14 |
| CHL | 374 | 1.07 | 0.43 | 0.99 | 1.05 | 1.13 | 4.01 | 0.23 |
| COL | 176 | 1.08 | 0.29 | 1.00 | 1.06 | 1.14 | 2.22 | 0.21 |
| CRI | 317 | 1.03 | 0.46 | 0.97 | 1.03 | 1.08 | 2.26 | 0.16 |
| CZE | 392 | 1.02 | 0.33 | 0.98 | 1.02 | 1.07 | 1.87 | 0.16 |
| DEU | 386 | 1.03 | 0.64 | 0.99 | 1.02 | 1.06 | 2.14 | 0.13 |
| DNK | 374 | 1.03 | 0.22 | 0.98 | 1.02 | 1.06 | 2.62 | 0.17 |
| ESP | 397 | 1.03 | 0.31 | 0.98 | 1.02 | 1.07 | 2.48 | 0.16 |
| EST | 375 | 1.03 | 0.33 | 0.98 | 1.02 | 1.06 | 2.41 | 0.19 |
| FIN | 371 | 1.04 | 0.45 | 0.98 | 1.02 | 1.07 | 2.31 | 0.16 |
| FRA | 392 | 1.03 | 0.01 | 0.97 | 1.02 | 1.07 | 2.69 | 0.19 |
| GBR | 350 | 1.04 | 0.32 | 0.98 | 1.03 | 1.08 | 2.57 | 0.17 |
| GRC | 390 | 1.02 | 0.49 | 0.97 | 1.01 | 1.06 | 2.44 | 0.15 |
| HUN | 385 | 1.05 | 0.40 | 0.99 | 1.04 | 1.08 | 3.42 | 0.20 |
| IRL | 384 | 1.03 | 0.26 | 0.98 | 1.02 | 1.06 | 1.91 | 0.17 |
| ISL | 362 | 1.02 | 0.42 | 0.94 | 1.02 | 1.10 | 2.10 | 0.16 |
| ISR | 347 | 1.02 | 0.41 | 0.94 | 1.00 | 1.08 | 2.40 | 0.17 |
| ITA | 386 | 1.02 | 0.60 | 0.98 | 1.02 | 1.06 | 2.00 | 0.12 |
| JPN | 331 | 1.05 | 0.58 | 0.97 | 1.03 | 1.11 | 2.37 | 0.19 |
| KOR | 343 | 1.02 | 0.47 | 0.95 | 1.01 | 1.06 | 2.10 | 0.16 |
| LTU | 378 | 1.03 | 0.45 | 0.98 | 1.01 | 1.06 | 2.21 | 0.16 |
| LUX | 378 | 1.03 | 0.33 | 0.99 | 1.02 | 1.05 | 2.65 | 0.22 |
| LVA | 375 | 1.04 | 0.29 | 0.98 | 1.02 | 1.07 | 3.46 | 0.22 |
| MEX | 294 | 1.06 | 0.34 | 0.99 | 1.05 | 1.12 | 1.81 | 0.13 |
| NLD | 388 | 1.03 | 0.59 | 0.98 | 1.02 | 1.06 | 3.88 | 0.20 |
| NOR | 379 | 1.06 | 0.41 | 1.01 | 1.05 | 1.09 | 1.96 | 0.14 |
| NZL | 330 | 1.05 | 0.65 | 0.98 | 1.03 | 1.09 | 2.58 | 0.17 |
| POL | 380 | 1.03 | 0.58 | 0.98 | 1.03 | 1.07 | 1.70 | 0.13 |
| PRT | 390 | 1.03 | 0.28 | 0.98 | 1.02 | 1.06 | 2.25 | 0.16 |
| SVK | 378 | 1.02 | 0.37 | 0.98 | 1.02 | 1.06 | 2.02 | 0.15 |
| SVN | 379 | 1.02 | 0.40 | 0.98 | 1.02 | 1.05 | 2.75 | 0.18 |
| SWE | 380 | 1.04 | 0.24 | 0.99 | 1.03 | 1.07 | 4.00 | 0.24 |
| TUR | 342 | 1.16 | 0.49 | 1.06 | 1.14 | 1.24 | 2.58 | 0.20 |
| USA | 324 | 1.03 | 0.51 | 0.98 | 1.01 | 1.06 | 2.89 | 0.17 |

Source: Authors' calculation using UN Comtrade.

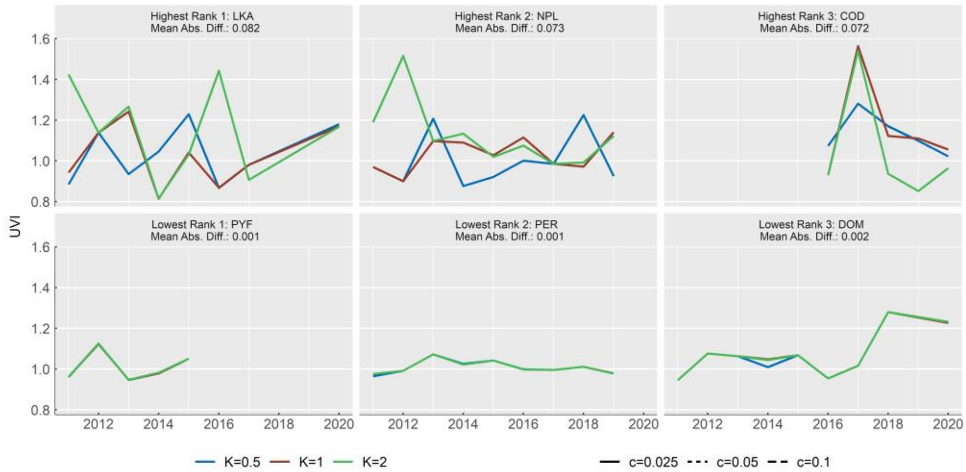
# Annex G. Parameter simulation

## Figure G.1. Parameter simulation with respect to choice of K and c in AFM outlier detection method, Rice imports (HS 1006)

A. OECD countries




B. Non-OECD countries




Source: Authors' calculation using UN Comtrade.