Annexe A. Methodological notes

A.1. Primary and secondary markets

In order to distinguish fake products for sale by counterfeiters on the primary market from those intended for sale on the secondary market, the price difference between both types of counterfeits is calculated. For each seizure entered into the World Customs Organization (WCO) and European Commission Directorate-General for Taxation and Customs Union (DG TAXUD) databases, customs authorities report the infringed trademark, the declared value of goods, the quantity seized and the product's Harmonised System (HS) code. This allows the unit value of each seized "product type-brand" pair to be determined ("brand" includes the associated trademark or patent). These unit values can then serve as a proxy for the retail prices of fake goods.

For each type of product associated with a given trademark or patent, the prices of seized goods are used to estimate a confidence interval that contains the actual retail price of the corresponding genuine item. Counterfeit items whose unit price, calculated as described above, is higher than or included in this interval are then classified as intended for sale on the primary market. Those whose price is below this interval are classified as targeting the secondary market.

Formally, let s_c and $\bar{s}_c$ denote, respectively, the import value and quantity of any custom seizure of counterfeit products, with $c \in \{1, \ldots, N\}$ the range of customs seizures and N their total number. $p_c = s_c/\bar{s}_c$ then refers to the unit value of each custom seizure and can serve as a proxy for their unit price. Let $p_{bp} = \left(\sum_{c\in\{bp\}} p_c\right)/N_{bp}$ define the (unweighted) price average of any type of product p associated with the brand or patent b, with N_{bp} the total number of custom seizures reported for this "product category-brand" combination. The standard deviation of this price is denoted σ_{bp}.

X_c is defined as a dichotomous (binary) variable that takes the value of 0 if the fake goods included in the seized shipment were intended to be sold on the primary market, or 1 if they were intended to be sold on the secondary market. In accordance with the arguments mentioned in the main text, X_c is assumed to be defined as follows:

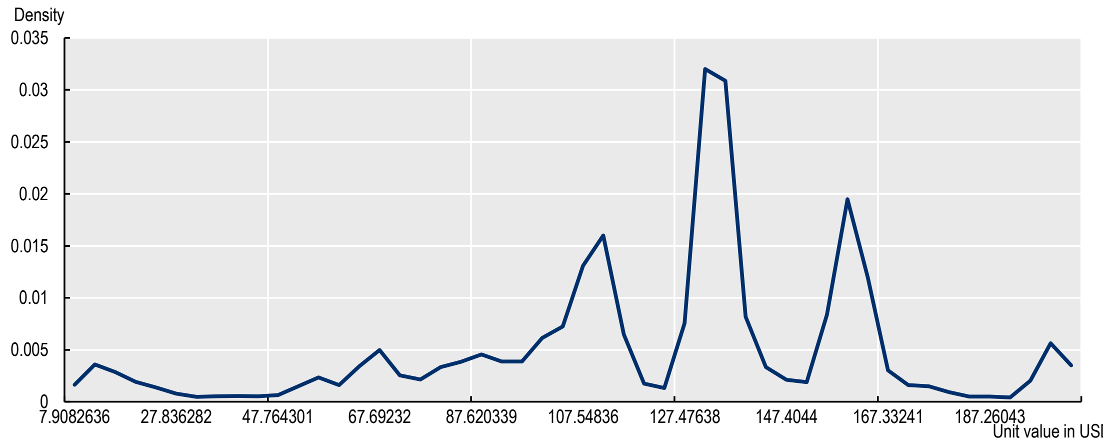
$$X_c = \begin{cases} = 0 \text{ if } p_c \in \left[p_{bp} - \frac{1.96 \times \sigma_{bp}}{\sqrt{N_{bp}}};\ \max\limits_{c\epsilon\{bp\}} p_c\right] \\ = 1 \text{ if } p_c \,\epsilon \left[\min\limits_{c\epsilon\{bp\}} p_c\,;\ p_{bp} - \frac{1.96 \times \sigma_{bp}}{\sqrt{N_{bp}}}\right[\end{cases}; \qquad \forall c\{bp\}$$

It follows that the share of products sold on the primary market can be calculated by product category, τ_p^1, and/or for the entire mass of fake imports, and is given by:

$$\tau_p^1 = \left(\sum_b \sum_c x_c s_c\right) / \left(\sum_b \sum_c s_c\right), \quad \forall c\epsilon\{bp\}$$

For example, Figure A A.1 shows the price distribution of fake shoes of brand X that were seized by global customs between 2014 and 2016. Using the methodology outlined above, this indicates that most fake X shoes with prices lower than USD 121 were destined for the secondary market, while those with values higher than USD 121 (observations in the middle and on the right-hand side of the distribution) were targeted at the primary market.

Figure A A.1. Price distribution of fake shoes of brand X seized by global customs, 2014-16



A.2. Constructing the General Trade-Related Index of Counterfeiting for products (GTRIC-p)

GTRIC-p is constructed through four steps:

1. For each reporting economy, the seizure percentages for sensitive goods are calculated.
2. For each product category, aggregate seizure percentages are calculated, taking the reporting economies' share of total sensitive imports as weights.
3. From these, a counterfeit source factor is established for each industry, based on the industries' weight in terms of total trade.
4. Based on these factors, the GTRIC-p is calculated.

Step 1: Measuring reporter-specific product seizure intensities

$\tilde{v}_i^k$ and $\tilde{m}_i^k$ are, respectively, the seizure and import values of product type *k* (as registered according to the HS on the two-digit level) in economy *i* from *any* provenance economy in a given year. Economy *i*'s relative seizure intensity (seizure percentages) of good *k*, denoted below as γ_i^k is then defined as:

$$\gamma_i^k = \frac{\tilde{v}_i^k}{\sum_{k=1}^{\bar{K}} \tilde{v}_i^k}, \text{ such that } \sum_{k=1}^{\bar{K}} \gamma_i^k = 1 \ \forall \ i \ \in \{1, \ldots, \bar{N}\}$$

$k = \{1, \ldots, \bar{K}\}$ is the range of sensitive goods (the total number of goods is given by *K*) and $i = \{1, \ldots, \bar{N}\}$ is the range of reporting economies (the total number of economies is given by *N*).

Step 2: Measuring general product seizure intensities

The general seizure intensity for product *k*, denoted $\boldsymbol{\Gamma^k}$, is then determined by averaging seizure intensities, γ_i^k, weighted by the reporting economies' share of total sensitive imports in a given product category, *k*. Hence:

$$\Gamma^k = \sum_{i=1}^{\bar{N}} \omega_i \gamma_i^k \ , \forall \ k \ \in \{1, \ldots, \bar{K}\}$$

The weight of reporting economy *i* is given by:

$$\omega_i = \frac{\widetilde{m}_i^k}{\sum_{i=1}^{\bar{N}} \widetilde{m}_i^k}$$

where $\widetilde{m}_i$ is *i*'s total registered import value of sensitive goods ($\sum_{i=1}^{\bar{n}} \omega_i = 1$)

Step 3: Measuring product-specific counterfeiting factors

$\widetilde{M}_i^k = \sum_{i=1}^{N} \widetilde{m}_i^k$ is defined as the total registered imports of sensitive good *k* for *all* economies and $\widetilde{M} = \sum_{k=1}^{\bar{K}} \widetilde{M}^k$ is defined as the total registered world imports of *all* sensitive goods.

The world import share of good *k,* denoted s^k, is therefore given by:

$$s^k = \frac{\widetilde{M}^k}{\widetilde{M}}, \text{ such that } \sum_{k=1}^{\bar{K}} s^k = 1$$

The general counterfeiting factor of product category *k*, denoted CP^k, is then determined as the following:

$$CP^k = \frac{\Gamma^k}{s^k}$$

The counterfeiting factor reflects the sensitivity of product infringements occurring in a particular product category, relative to its share in international trade. These are based on the seizure percentages calculated for each reporting economy and constitute the foundation of the formation of GTRIC-p.

Step 4: Establishing GTRIC-p

GTRIC-p is constructed from a transformation of the general counterfeiting factor and measures the relative likelihood that different product categories will be subject to counterfeiting and piracy in international trade. The transformation of the counterfeiting factor is based on two main assumptions:

- Assumption (A1): The counterfeiting factor of a particular product category is positively correlated with the actual intensity of international trade in counterfeit and pirated goods covered by that chapter. The counterfeiting factors must thus reflect the real intensity of actual counterfeit trade in the given product categories.
- Assumption (A2): This acknowledges that the assumption A1 may not be entirely correct. For instance, the fact that infringing goods are detected more frequently in certain categories could imply that differences in counterfeiting factors across products merely reflect that some goods are easier to detect than others or that some goods, for one reason or another, have been specially targeted for inspection. The counterfeiting factors of product categories with lower counterfeiting factors could, therefore, underestimate actual counterfeiting and piracy intensities in these cases.

In accordance with assumption A1 (positive correlation between counterfeiting factors and actual infringement activities) and assumption A2 (lower counterfeiting factors may underestimate actual activities), GTRIC-p is established by applying a positive monotonic transformation of the counterfeiting factor index using natural logarithms. This standard technique of linearisation of a non-linear relationship (in the case of this study between counterfeiting factors and actual infringement activities) allows the index to be flattened and gives a higher relative weight to lower counterfeiting factors (Verbeek, 2000[17]).

In order to address the possibility of outliers at both ends of the counterfeiting factor index (i.e. some categories may be measured as particularly susceptible to infringement even though they are not, whereas others may be measured as insusceptible although they are), it is assumed that GTRIC-p follows a left-truncated normal distribution, with GTRIC-p only taking values of zero or above.

The transformed counterfeiting factor is defined as:

$$cp^k = \ln(CP^k + 1)$$

Assuming that the transformed counterfeiting factor can be described by a left-truncated normal distribution with $cp^k \geq 0$, then, following Hald (1952[18]), the density function of GTRIC-p is given by:

$$f_{LTN}\,(cp^k) = \begin{Bmatrix} 0 & if\ cp^k \leq 0 \\ \dfrac{f\,(cp^k)}{\int_0^{\infty} f\,(cp^k) dcp^k} & if\ cp^k \geq 0 \end{Bmatrix}$$

where $f(cp^k)$ is the non-truncated normal distribution for cp^k specified as:

$$f(cp^k) = \frac{1}{\sqrt{2\pi\sigma_{cp}^2}}\, exp\left(-\frac{1}{2}\left(\frac{(cp^k) - \mu_{cp}}{\sigma_{cp}}\right)^2\right)$$

The mean and variance of the normal distribution, here denoted μ_{cp} and σ_{cp}^2, are estimated over the transformed counterfeiting factor index, cp^k, and given by $\hat{\mu}_{cp}^2$ and σ_{cp}^2. This enables the calculation of the counterfeit import propensity index (GTRIC-p) across HS codes, corresponding to the cumulative distribution function of cp^k.

A.3. Constructing the general trade-related index of counterfeiting economies (GTRIC-e)

GTRIC-e is also constructed through four steps:

1. For each reporting economy, the seizure percentages for provenance economies are calculated.
2. For each provenance economy, aggregate seizure percentages are calculated, taking the reporting economies' share of total sensitive imports as weights.
3. From these, each economy's counterfeit source factor is established, based on the provenance economies' weight in terms of total trade.
4. Based on these factors, the GTRIC-e is calculated.

Step 1: Measuring reporter-specific seizure intensities from each provenance economy

$\tilde{v}_i^j$ is economy i's registered seizures of all types of infringing goods (i.e. all *k*) originating from economy *j* in a given year in terms of their value. γ_i^j is economy *i*'s relative seizure intensity (seizure percentage) of all infringing items that originate from economy *j*, in a given year:

$$\gamma_i^j = \frac{\tilde{v}_i^j}{\sum_{j=1}^{\bar{J}} \tilde{v}_i^j} \text{ such that } \sum_{j=1}^{\bar{J}} \gamma_i^j = 1\ \forall\, i\ \in \{1, \dots, \bar{N}\}$$

Where $j = \{1, \dots, \bar{J}\}$ is the range of identified provenance economies (the total number of exporters is given by *J*) and $i = \{1, \dots, \bar{N}\}$ is the range of reporting economies (the total number of economies is given by *N*).

Step 2: Measuring general seizure intensities of each provenance economy

The general seizure intensity for economy *j*, denoted Γ^j, is then determined by averaging seizure intensities, γ_i^j, weighted by the reporting economy's share of total imports from known counterfeit and pirate origins.[1] Hence:

$$\Gamma^j = \sum_{i=1}^{\bar{N}} \omega_i \gamma_i^j \text{ , } \forall j \in \{1, \dots, \bar{J}\}$$

The weight of reporting economy *i* is given by:

$$\omega_i = \frac{\tilde{m}_i^j}{\sum_{i=1}^{\bar{N}} \tilde{m}_i^j}, \text{ such that } \sum_{i=1}^{\bar{N}} \omega_i = 1$$

Step 3: Measuring partner-specific counterfeiting factors

$\bar{M}_i^j = \sum_{i=1}^{N} \bar{m}_i^j$ is defined as the total registered world imports of all sensitive products from *j*,[2] and $\bar{M} = \sum_{j=1}^{\bar{J}} \bar{M}^j$ is the total world import of sensitive goods from all provenance economies.

The share of imports from provenance economy *j* in total world imports of sensitive goods, denoted s^j, is then given by:

$$s^j = \frac{\bar{M}^j}{\bar{M}}, \text{ such that } \sum_{j=1}^{\bar{J}} s^j = 1$$

From this, the economy-specific counterfeiting factor is established by dividing the general seizure intensity for economy *j* by the share of total imports of sensitive goods from *j*.

$$CE^j = \frac{\Gamma^j}{s^j}$$

Step 4: Establishing GTRIC-e

Gauging the magnitude of counterfeiting and piracy from a provenance economy perspective can be done in a similar fashion as for sensitive goods. Hence, a General Trade-Related Index of Counterfeiting for economies (GTRIC-e) is established along similar lines and assumptions:

- Assumption (A3): The intensity by which any counterfeit or pirated article from a particular economy is detected and seized by customs is positively correlated with the actual amount of counterfeit and pirate articles imported from that location.
- Assumption (A4): This acknowledges that assumption A3 may not be entirely correct. For instance, a high seizure intensity of counterfeit or pirated articles from a particular provenance economy could be an indication that the provenance economy is part of a customs profiling scheme or that it is specially targeted for investigation by customs. The importance that provenance economies with low seizure intensities play regarding actual counterfeiting and piracy activity could, therefore, be under-represented by the index and lead to an underestimation of the scale of counterfeiting and piracy.

As with the product-specific index, GTRIC-e is established by applying a positive monotonic transformation of the counterfeiting factor index for provenance economies using natural logarithms. This follows from assumption A3 (positive correlation between seizure intensities and actual infringement activities) and assumption A4 (lower intensities tend to underestimate actual activities). Considering the possibilities of outliers at both ends of the GTRIC e-distribution (i.e. some economies may be wrongly measured as being particularly susceptible sources of counterfeit and pirated imports, and vice versa), GTRIC-e is approximated by a left-truncated normal distribution as it does not take values below zero.

The transformed general counterfeiting factor across provenance economies on which GTRIC-e is based is therefore given by applying logarithms onto economy-specific general counterfeit factors (see, for example, Verbeek (2000[17])):

$$ce^j = ln(CE^j + 1)$$

In addition, following GTRIC-p, it is assumed that GTRIC-e follows a truncated normal distribution with $ce^j \geq 0$ for all *j*. Following Hald (1952[18]), the density function of the left-truncated normal distribution for ce^j is given by:

$$g_{LTN}(ce^j) = \begin{cases} 0 & if\ ce^j \leq 0 \\ \dfrac{g(ce^j)}{\int_0^\infty g(ce^j)dce} & if\ ce^j \geq 0 \end{cases}$$

where $g(ce^j)$ is the non-truncated normal distribution for ce^j specified as:

$$g(ce^j) = \frac{1}{\sqrt{2\pi\sigma_{ce}^2}} exp\left(-\frac{1}{2}\left(\frac{ce^j - \mu_{ce}}{\sigma_{ce}}\right)^2\right)$$

The mean and variance of the normal distribution, here denoted μ_{ce} and σ_{ce}^2, are estimated over the transformed counterfeiting factor index, ce^j, and given by $\hat{\mu}_{ce}$ and $\hat{\sigma}_{ce}^2$. This enables the calculation of the counterfeit import propensity index (GTRIC-e) across provenance economies, corresponding to the cumulative distribution function of ce^j.

A.4. Constructing the General Trade-Related Index of Counterfeiting (GTRIC)

In the OECD (2008[19]) and OECD/EUIPO (2016[7]) studies, propensities to import infringing goods from different trading partners were developed using seizure data as a basis. The use of data is maximised by applying a generalised approach in which the propensities for products to be counterfeit and for economies to be sources of counterfeit goods were analysed separately. This increased the data coverage of both products and provenance economies significantly, which increases the robustness of the overall estimation results. Unfortunately, it also reduced the detail of the analysis, meaning that counterfeit trade patterns specific to individual reporting economies, for both product types and trading partners, were not simultaneously accounted for; this introduced bias into the results. On balance, however, given the large scope of the analysis, the advantages of increasing data coverage can be viewed as outweighing the biases.

This approach combines the two indices: GTRIC-p and GTRIC-e. In this regard, it is important to emphasise that the index resulting from this combination does not account for differences in infringement intensities across different types of goods that may exist between economies. For instance, imports of certain counterfeit and pirated goods could be particularly large from some trading partners and small from others. An index taking such “infringement specialisation”, or concentration, into account is desirable and possible to construct; but it would require detailed seizure data. The combined index, denoted GTRIC, is,

therefore, a generalised index that approximates the relative likelihoods that particular product types, imported from specific trading partners, are counterfeit and/or pirated.

Establishing likelihoods for product and provenance economy

In this step, for each trade flow from a given provenance economy and for a given product category the likelihoods of containing counterfeit and pirated products will be established.

The general propensity for an economy to export infringed items of HS category *k* is denoted P^k, and given by GTRIC-p, so that:

$$P^k = F_{LTN}(cp^k)$$

where $F_{LTN}(cp^k)$ is the cumulative probability function of $f_{LTN}(cp^k)$.

Furthermore, the general likelihood of importing any type of infringing goods from economy *j* is denoted as P^j , and given by GTRIC-e, so that:

$$P^j = G_{LTN}(ce^j)$$

where $G_{LTN}(ce^j)$ is the cumulative probability function of $f_{LTN}(ce^j)$.

The general probability of importing counterfeit or pirated items of type *k* originating from economy *j* is then denoted P^{jk} and approximated by:

$$P^{jk} = P^k P^j$$

Therefore, $P^{jk} \in [\varepsilon_p \varepsilon_e; 1), \forall j, k$, with $\varepsilon_p \varepsilon_e$ denoting the minimum average counterfeit export rate for each sensitive product category and each provenance economy,[3] it is assumed that $\varepsilon_p = \varepsilon_e = 0.05$.

A.5. Calculating the absolute value

α is the fixed point, i.e. the maximum average counterfeit import rate of a given type of infringing good, *k*, originating from a given trading partner, *j*.

α can be applied to propensities for importing infringing goods of type *j* from trading partner *k* (αP^{jk}). As a result, a matrix of counterfeit import propensities **C** is obtained**.**

$$\boldsymbol{C} = \begin{pmatrix} \alpha P^{11} & \alpha P^{21} & & & \alpha P^{1K} \\ \alpha P^{12} & \ddots & & & \\ \vdots & & \alpha P^{jk} & & \vdots \\ & & & \ddots & \\ \alpha P^{J1} & & & & \alpha P^{JK} \end{pmatrix} \text{ with dimension } J \times K$$

The matrix of world imports is denoted by **M.** Applying **C** on **M** yields the absolute volume of trade in counterfeit and pirated goods.

In particular, the import matrix **M** is given by:

$$\boldsymbol{M} = \begin{pmatrix} \boldsymbol{M}_1 \\ \vdots \\ \boldsymbol{M}_i \\ \vdots \\ \boldsymbol{M}_n \end{pmatrix} \text{ with dimension n x J x K}$$

Each element is defined by economy *i*'s unique import matrix of good *k* from trading partner *j*.

$$\boldsymbol{M_i} = \begin{pmatrix} \boldsymbol{m_{i1}^1} & \boldsymbol{m_{i1}^2} & & & \boldsymbol{m_{i1}^K} \\ \boldsymbol{m_{i2}^1} & \ddots & & & \\ \vdots & & \boldsymbol{m_{ij}^k} & & \vdots \\ & & & \ddots & \\ \boldsymbol{m_{iJ}^1} & & & & \boldsymbol{m^{JK}} \end{pmatrix} \text{ with dimension } J \text{ x } K$$

Hence, the element m_{ij}^k denotes *i*'s imports of product category *k* from trading partner *j*, where $i = \{1, \dots, n\}$, $j = \{1, \dots, J\}$, and $k = \{1, \dots, K\}$.

Denoted by Ψ, the product-by-economy percentage of counterfeit and pirated imports can be determined as the following:

$$\Psi = \boldsymbol{C'M} \div \boldsymbol{M}$$

Total trade in counterfeit and pirated goods, denoted by the scalar **TC**, is then given by:

$$\boldsymbol{TC} = \boldsymbol{i}_1{}'\Psi\boldsymbol{i}_2$$

where $\boldsymbol{i}_1$ is a vector of one with dimension *nJ* x 1, and $\boldsymbol{i}_2$ is a vector of one with dimension *K* x 1. Then, by denoting total world trade by the scalar $\boldsymbol{TM} = \boldsymbol{i}_1{}'\boldsymbol{M}\boldsymbol{i}_2$, the value of counterfeiting and piracy in world trade, s_{TC}, is determined by:

$$s_{TC} = \frac{\boldsymbol{TC}}{\boldsymbol{TM}}$$

A.6. Consumer detriment

Individual consumer detriment is the price premium unjustly paid by the consumer in the belief they are buying a genuine product. As consumers who choose to purchase counterfeit products on secondary markets deliberately accept a cost-quality trade-off, consumer detriment only occurs in primary markets. For each product category, the individual consumer detriment is estimated by calculating the difference between the average price paid in the primary market (by deceived consumers) and that paid in the secondary market (by consumers who knowingly buy fake goods). This individual consumer detriment is then multiplied by the total volume of transactions in the primary market in a given product category. Finally, for all product categories, the detriments are added together to give a general estimate of overall consumer detriment.

More formally, the principle behind the measure of consumer detriment is as follows. First, for any type of product p related to brand b, the average price paid on the primary market, p_{bp}^1, and the average price paid on the secondary market, p_{bp}^2, are calculated. Since the gap between these prices represents the "value of consumers' deception", it can be used as a proxy for the consumer detriment of purchasing a given branded product bp on the primary market: $d_{bp} = p_{bp}^1 - p_{bp}^2$. Finally, these detriments can be aggregated by product category or, at the national level, by multiplying them by the estimated volume of sales on primary markets, Q_{bp}^1, as follows: $D = \sum_b \sum_p \left(d_{bp} Q_{bp}^1\right)$.

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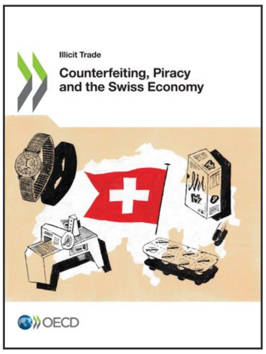

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