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Recent trends in transport and insurance costs and estimates at disaggregated product level

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Recent trends in transport and insurance costs and estimates at disaggregated product level

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Abstract

This paper updates the OECD International Transport and Insurance Cost (ITIC) of Merchandise Trade database, which covers more than 180 countries and partners, and over 1000 products from 1995 to 2020. Transport and insurance costs, also known as CIF-FOB margins, are estimated using a gravity model. A cross-validation procedure is used to evaluate model performance. In addition to describing the methodology, the paper highlights that transport and insurance costs are declining as a fraction of trade value, but this reduction has been flattening out in more recent years. However, an alternative measure, the explicit CIF-FOB margins per kilogramme imported, suggests that transport and insurance costs have been actually rising since 2002. Both CIF-FOB margins and cost per kilogramme imported show increases in 2020 when compared to 2019. This is robust to corrections for compositional changes. The methodology is used to produce the International Transport and Insurance Costs of Merchandise Trade data base and the data is made publically available on .Stat under the International Trade and Balance of Payments heading.

Keywords: International trade, transport and insurance costs, CIF-FOB margin, gravity model.

JEL classification: F14, L91, C23.

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Résumé

Ce document de travail met à jour la base de données de l'OCDE sur les coûts internationaux de transport et d'assurance (ITIC) du commerce de marchandises, qui couvre plus de 180 pays et partenaires, et plus de 1 000 produits sur la période 1995-2020. Les coûts de transport et d'assurance, également connus sous le nom de marges *CAF-FAB*, sont estimés à l'aide d'un modèle de gravité dans. L'étude introduit aussi une procédure de validation croisée pour évaluer la performance du modèle. Outre la description de la méthodologie, l'analyse souligne que les coûts de transport et d'assurance diminuent en tant que fraction de la valeur commerciale, mais que cette réduction s'est stabilisée au cours des dernières années. Cependant, l'utilisation d'une mesure alternative, à savoir les marges explicites *CAF-FAB* par kilogramme importé, suggère que les coûts de transport et d'assurance ont en fait augmenté depuis 2002. Les marges CAF-FAB et le coût par kilogramme ont augmenté entre 2019 et 2020. Ce résultat est robuste à une correction pour prendre en compte des changes de composition. 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 : Commerce international, coûts de transport et d'assurance, marge CAF-FOB, modèle gravitaire.

Classifications JEL : F14, L91, C23.

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1. Introduction

Transport and insurance costs, usually expressed as CIF-FOB margins, remain important determinants of the volume and geography of international trade today. Many researchers have highlighted how these trade costs associated with, for example, poor quality infrastructure (ports, roads), geographical distance to market, language and colonial ties, and bilateral and multilateral agreements, continue to shape global production networks and countries' integration into global value chains (Hummels, 1999; UNCTAD and World Bank, 2021; Behar and Venables, 2011; Moïsé and Sorescu, 2019).

This paper presents the latest update of the International Transport and Insurance Cost (ITIC) of merchandise trade database. It reports estimates of CIF-FOB margins for more than 180 countries and partners and for more than 1000 products. Compared to the previous update in 2018, the time coverage of the database has been extended by four years, and it covers 1995 to 2020.

The majority of countries does not report *explicit data* on transport and insurance costs, namely import statistics in both CIF and FOB valuation at detailed product level. But since the last update of the ITIC database in 2018, the number of countries that provide underlying explicit data has doubled: seventeen countries started to provide imports data in both CIF and FOB valuations to the UN in recent years. Moreover, a handful of countries, which provided exports in both CIF and FOB valuations, were also tested but not included in the analysis due to quality concerns. All countries reported explicit transport and insurance costs for import flows can be found in table A.1. In addition to the coverage expansion, one main novelty of the paper is to use a cross validation procedure to assess the model's out-of-sample performance.

Transport and insurance costs are often believed to have been reduced in the past largely due to the standardised shipping practices (i.e. through the deployment of standardised shipping containers) and efficiency gains at large ports. The explicit CIF-FOB margins point to, indeed, an on-going reduction in transport and insurance costs, although the reduction has slowed down since 2010. These changes in CIF-FOB margins are also partially explained by shifts in the trade composition over the years, i.e. the countries with low margins import more products or the products with low margins are traded more frequently nowadays than was the case in the past. On the contrary, looking at a different metric, the cost of transporting one kilogramme of any given product is found to have been actually rising since 2002, once controlling for the weights of the imported products.

The paper is structured as follows. A brief overview of the methodology is presented in Section 2. Section 3 presents the main trends in transport and insurance costs as observed in the explicit data and in adjusted trends accounting for trade compositional effects and for the weights of imported products. Section 4 introduces the gravity model used and presents the cross-validation results. Main insights obtained from the estimations of the gravity model are discussed in Section 5. Section 6 concludes.

2. Overview of the methodology

CIF-FOB margins have been estimated in two strands of the literature with either the aim of explaining the size, trends and drivers of trade costs (Hummels, 1999; Limao and Venables, 2001; Hummels and Skiba, 2004; Hummels and Lugovskyy, 2006; Pomfret and Sourdin, 2010; Sourdin and Pomfret, 2012) or with the objective of developing international trade statistics (Gaulier et al., 2008; Gaulier and Zignago, 2010; Timmer et al., 2012; Streicher and Stehrer, 2013; UNCTAD and World Bank, 2021).

There are two distinctive approaches to estimating CIF-FOB margins. The first one is often referred to as explicit data on transport costs, published by statistical offices. The most prominent examples are Hummels and Skiba (2004), Clark et al. (2004), UNCTAD and World Bank (2021). The second one is referred to as implicit data on transport costs, which are drawn from UN COMTRADE database and simply capture the differences between the mirrored flows – imports in CIF and exports in FOB prices (Ghelhar, 1996; Gaulier et al., 2008; Gaulier and Zignago, 2010).

The approach used to develop the OECD database on ITIC relies on the first strand and follows a two-step process. First, this paper adopts a methodology similar to Hummels and Skiba's (2004) and uses explicit trade data at HS 6-digit product level available for 33 countries to derive CIF-FOB margins over the period 1995-2020 to estimate a gravity model. Exporting data with both CIF and FOB values at detailed product level are also tested for Honduras, Rwanda, Serbia and Namibia, but were not used due to quality concerns. Second, the gravity-model coefficients are used to derive estimates for those countries which do not have explicitly reported CIF-FOB margins. The remaining data that could not be estimated by the model (due to missing explanatory variables or missing quantities following confidentiality rules) are interpolated using standard statistical approaches. The final ITIC database consists of a combination of explicitly reported data and model estimates. For countries that do have explicitly reported data but not for all periods, model estimates are readjusted to explicitly reported data and to fill the gaps. The results reported here do not mix explicitly reported data and model estimates.

The gravity model has been also tested further for robustness across a broader set of countries, using implicit CIF-FOB margins derived from the UN COMTRADE database (Miao and Fortanier, 2017), and it highlights that estimates are likely to capture other reasons causing trade asymmetries between reporters and partners, i.e. conceptual differences between country of consignment (for imports) and first destination (for exports), as well as other statistical errors.

In addition, the gravity model approach with explicit CIF-FOB measures has been refined with a cross-validation procedure, in order to select the best model and estimate missing observations.

3. CIF-FOB margins for country/year where explicit data are available

3.1. Main observations

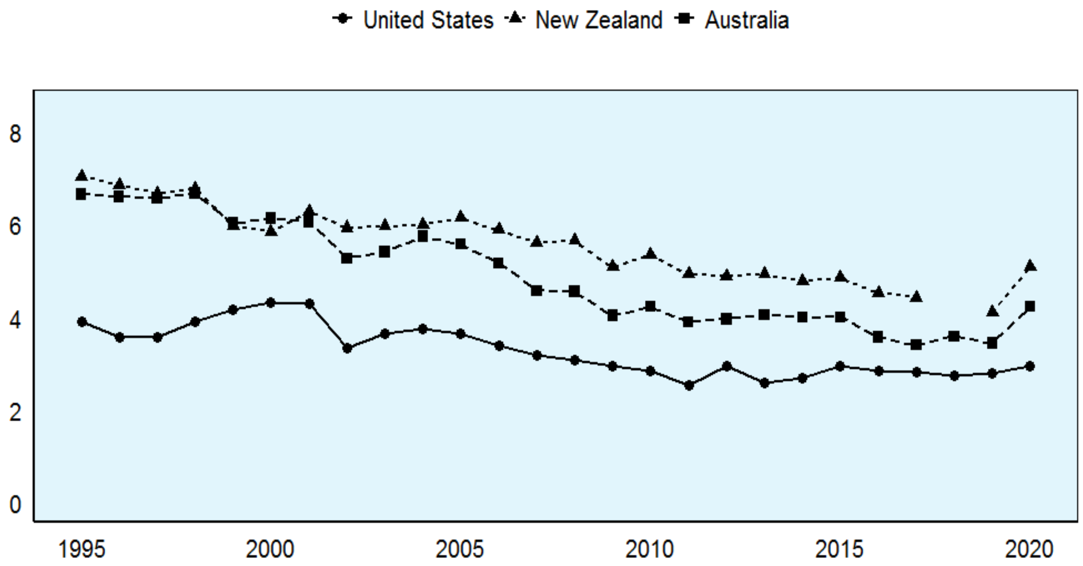
CIF-FOB margins, derived from explicit data (see table A.1 for an overview of reporting countries) point to the following observations (Figure 1):

- Most of emerging-market economies face higher aggregate CIF-FOB margins than developed countries;
- The decline in margins since 1995 is more pronounced in Australia, New Zealand, Peru and Chile than in the United States and Brazil; and
- Most of the countries that reported explicit CIF-FOB costs have seen a pick-up in transport and insurance costs in 2020.

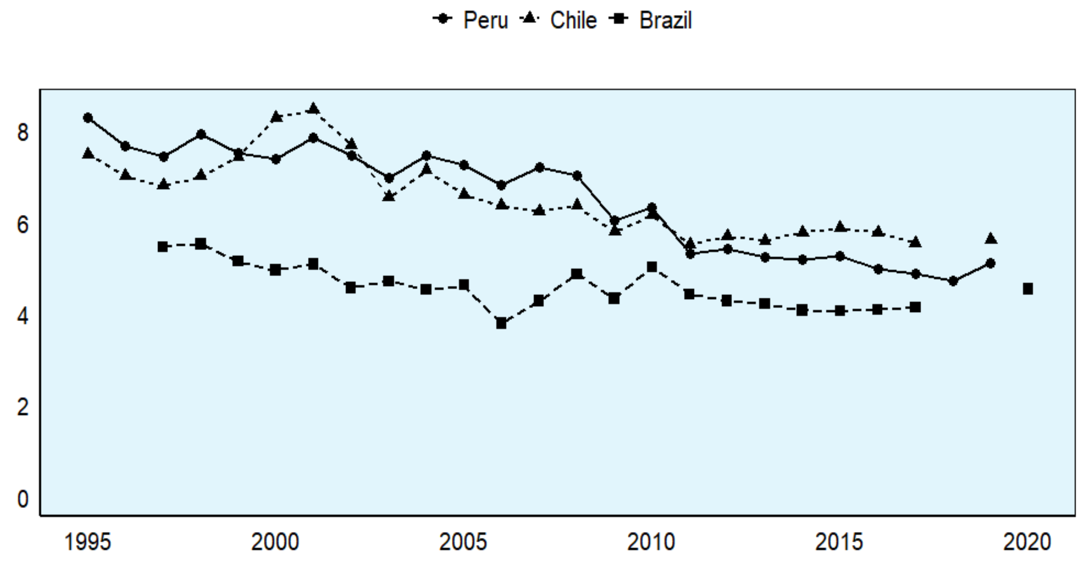
Data for more countries are available in Annex A.

Figure 1. CIF-FOB weighted average margins, per cent

a. Advanced economies



b. Emerging-market economies



Note: Margins are defined as (CIF-FOB)/CIF at the HS-6 digit level and aggregated using CIF price as weights. Not all countries have provided the explicit data to the UN at both CIF and FOB valuations for the entire period 1995-2020, hence the data gaps for New Zealand, Chile, and Brazil (Figure 1).
Source: UN COMTRADE and US Census Bureau.

CIF-FOB margins vary widely across different chapters, which correspond to the two-digit taxonomy of the Harmonised System, a classification widely used in reporting international merchandise trade statistics (Table 1). *Precious stones*, *aircrafts* and *pharmaceutical products* often record the lowest margins. The transport and insurance costs also vary across trading partner countries (Table 2). For example, Ireland, Mexico, and Papua New Guinea are the three trading partners with the lowest CIF-FOB margins, while islands including Tonga, Nauru and Faroe Islands show the highest trade margins. Standard deviations generally seem to be high in both tables, which either points to significant noise in the explicit dataset or the importance of country-partner specific characteristics, such as distance and contiguity.

Table 1. HS Chapters with the highest and lowest CIF weighted average margins, 1995-2020

HS Chapter	Description	Weighted Mean	Standard Deviation	Number of observations
Panel A: Bottom Five Chapters				
71	Natural, cultured pearls; precious, semi-precious stones; precious metals, metals clad with precious metal, and articles thereof; imitation jewellery; coin	0.8%	5.1%	79065
88	Aircraft, spacecraft and parts thereof	0.9%	5.1%	28067
75	Nickel and articles thereof	1.0%	4.8%	21070
30	Pharmaceutical products	1.0%	4.8%	105440
98	Special classification provisions (in H0 & H1 classification only)	1.2%	5.2%	2437
Panel B: Top Five Chapters				
HS Chapter	**Description**	**Weighted Mean**	**Standard Deviation**	**Number of observations**
08	Fruit and nuts, edible; peel of citrus fruit or melons	9.8%	6.3%	80079
69	Ceramic products	10.2%	6.3%	104745
06	Trees and other plants, live; bulbs, roots and the like; cut flowers and ornamental foliage	12.1%	7.5%	16661
25	Salt; sulphur; earths, stone; plastering materials, lime and cement	12.8%	7.3%	76659
46	Manufactures of straw, esparto or other plaiting materials; basketware and wickerwork	14.5%	6.6%	17527

Note: Margins are defined as (CIF-FOB)/CIF at the HS-6 digit level and aggregated using CIF price as weights.
Source: UN COMTRADE and US Census Bureau.

Table 2: Countries with the highest and lowest CIF weighted average margins, 1995-2020

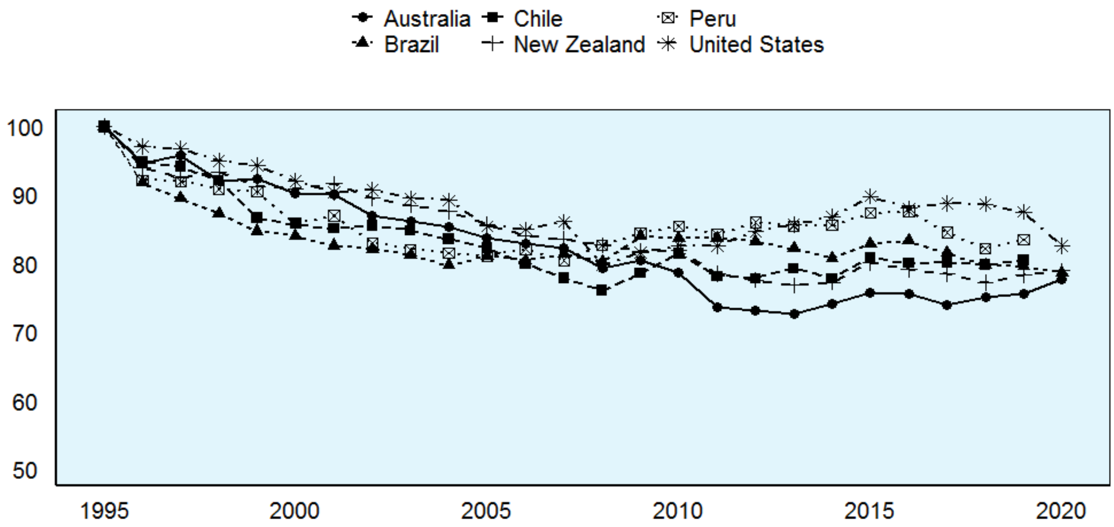
Trade Partner Country	Weighted Mean	Standard Deviation	Number of observations
Panel A: Bottom Five Trade Partner Countries			
Ireland	0.6%	5.6%	102107
Mexico	1.3%	5.4%	321822
Papua New Guinea	1.3%	6.1%	7751
Switzerland	1.5%	5.2%	327450
Sint Maarten	1.5%	6.7%	313
Panel B: Top Five Trade Partner Countries			
Trade Partner Country	**Weighted Mean**	**Standard Deviation**	**Number of observations**
Guinea	10.9%	7.2%	2179
Togo	11.8%	6.8%	1760
Tonga	13.7%	7.9%	1723
Nauru	16.1%	6.1%	1458
Faroe Islands	17.1%	5.5%	2324

Note: Margins are defined as (CIF-FOB)/CIF at the HS-6 digit level and aggregated using CIF price as weights.
Source: UN COMTRADE and US Census Bureau.

3.2. Adjustment for compositional effects and weights of traded products

Declining average margins can reflect a shift in the import composition (i.e. change of products imported over time or a shift in partner countries). This can, for example, happen when a country decides to import fewer goods from a certain partner country that has above average margins, resulting in a realised lower margin. Indeed, the Finger-Kreinin Index (Finger and Kreinin, 1979) demonstrates a 20% shift on the import composition from 1995, (Figure 2). The index is taken with respect to 1995 – a value of 100 means that the import composition is exactly the same as in 1995, while a value close to zero means it is completely different. The index steadily declined from 1995 to 2010, but has stabilised since 2010. Recent evidence suggest that the trade composition has also been altered in the aftermath of the COVID-19 crisis (Arriola, Kowalski, and van Tongeren, 2021).

Figure 2. Finger-Kreinin index for selected countries, imports at HS 2-digit levels



Note: the Finger-Kreinin Index measures the shifts in trade composition. The benchmark year is 1995 for this analysis. The index ranges between 0 and 100, where 0 means that imported products are completely different and 100 means that the imported products are unchanged, as compared to the reference year.
Source: Authors' calculation.

The motivation behind using cleaned/fitted margins was given by Hummels (2007) who showed clear differences in CIF-FOB margins and especially in the ad valorem ocean freight rates at the HS 2-digit level after correcting for compositional effects. CIF-FOB margins were corrected from composition effects by regressing the log margin on time dummies, allowing for a separate intercept for each country, reporter, HS 6-digit product, and quantity unit combination. More specifically, let γ_i be the sum of all non-time-varying dummies times their coefficients where the subscript i represents all possible combinations of reporting country, partner country, 6-digit HS code, and quantity unit. The model can be written as:

$$y_{it} = \alpha + \gamma_i + \beta\delta_t.$$

Assuming for example that only two time periods exist, 1995 and 1996, where δ_t is the dummy for 1996, and β denoting by how much $y_{i,t}$ is larger in 1996 with respect to 1995 levels keeping all else fixed. Including a dummy for all country, reporter, HS 6-digit code, and quantity unit combination would have resulted in too many coefficients to be estimated.

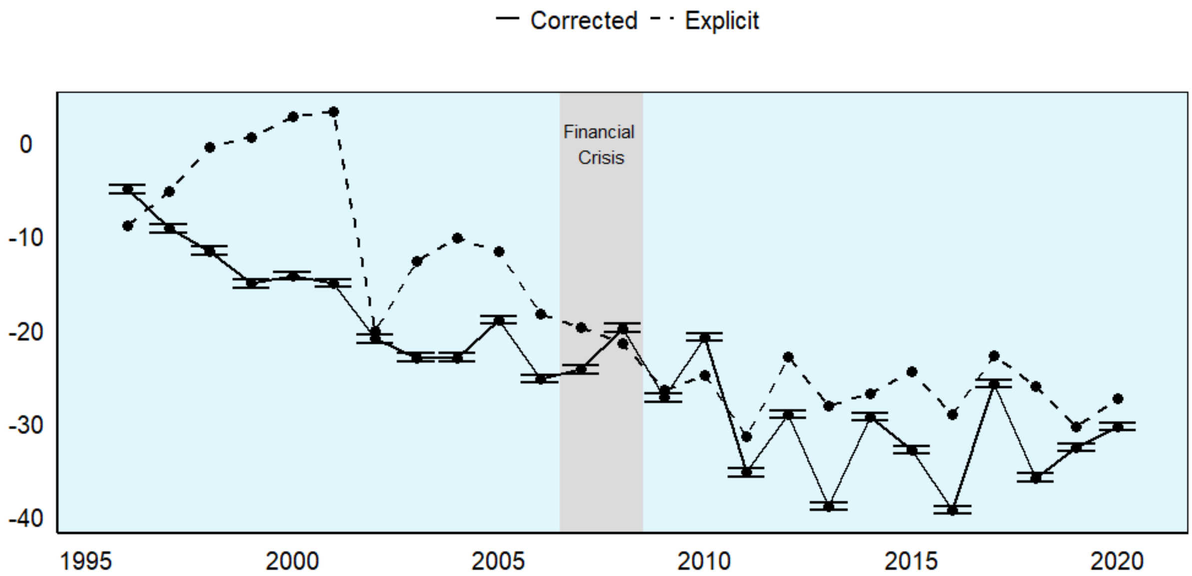
Applying a within transformation, the constant α and γ_i can be cancelled out, and the model can be rewritten:

$$\widehat{y_{it}} = y_{it} - \overline{y_i} = \beta(\delta_t - \overline{\delta_i}),$$

where $\overline{y_i} = \frac{1}{T}\sum y_{it}$ and $\overline{\delta_i}$ is the mean of δ_t within group i, i.e. what proportion of observations in group i in a given year t. This within transformation makes the estimation feasible, since this final equation contains only T-1 coefficients.

Accounting for both product and country/partner composition effects, the weighted average margin still shows a decreasing trend over time, which is lower than that of the unadjusted CIF-FOB margin but with an increase in volatility since 2005 (Figure 3). There was a rebound of margins in 2020, which is reflected in both explicit and corrected measures. In addition, the correction appears to be necessary at some specific points in time. For example, the explicit measure shows a decrease during the Global Financial Crisis, while the corrected measure shows a clear increase in 2007 and 2008, which is much more in line with the development of trade during that time.

Figure 3. Percentage difference of corrected and explicit margins with respect to 1995 levels



Note: Margins are defined as (CIF-FOB)/CIF at the HS-6 digit level and aggregated using CIF price as weights. The error bars show ± two standard errors.
Source: Authors' calculation.

The decrease in margins over time stands in contrast to the increase in the transport and insurance costs per kilogramme imported. This was calculated by dividing the cost (the difference between CIF and FOB prices) by the net weights (measured in kilogrammes), as provided by UN COMTRADE.[2] Afterwards, this measure was corrected for trade composition effects using the same within transformation, as indicated above. Formally, margins, transport and insurance cost per kilogramme, and the value of products per kilogramme are related as

$$\frac{Cost}{KG} = \frac{m}{1-m} * \frac{FOB}{KG}$$

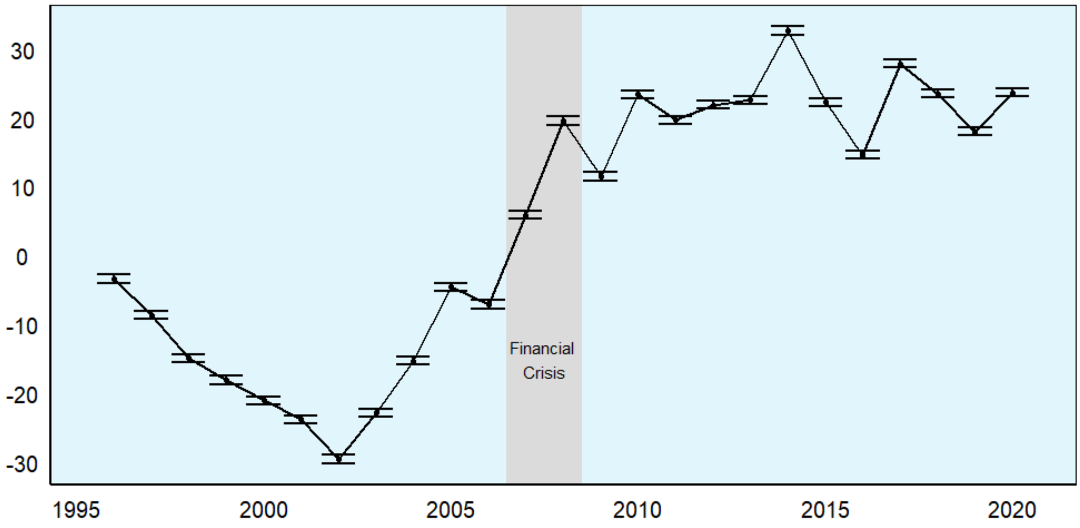
where m is the margin.

Figure 4 shows that costs per kilogramme for imports first followed the trend of margins and decreased until 2002, and stayed lower than the 1995 level until 2006. Since then, the costs per kilogramme has been significantly higher than that in 1995. In 2020, the costs of importing one kilogramme of a product on average, keeping everything else fixed, was around 23% above the 1995 level, but below the record level in 2014. It therefore seems like margins did not decrease due to an actual reduction in costs, but rather through a faster increase in the value per kilogramme imported than the increase in the cost of transporting that kilogramme.

The cost per kilogramme imported as reported here is different from shipping costs as traditionally measured. These are survey-based rates for well-specified transportation services such as shipping a forty foot container on a particular shipping lane. There is thus no guarantee that the cost per kilogramme and survey-based indices show the same development. Also, while quantities in customs data reflect the universe of transactions, the information is notoriously noisy and less timely than survey based indices. For example, the data at hand does not yet reflect the increase in shipping costs shown in measures of container shipping price indices in 2021. Thus, the cost per kilogramme measure is less suited for short-term analyses than for longer-term, structural purposes.

[2] UN COMTRADE data include a first quantity unit and second quantity unit. The first quantity code has 13 categories, such as kilograms, pairs, metres or cubic metres etc. The second unit is a complement measure for the first, weight in kilogramme if the first quantity is not already in kilograms. Weights in kilogramme were available for most observations in the explicit data (76%). For simplicity, only products with quantity unit in weights in kilograms are used for this chart. The import value per kilogramme was winsorised below at 0.1% and above at 99.9%. Removing more outliers would not drastically change the qualitative conclusions.

Figure 4. Costs of importing one kilogramme with respect to 1995 level; percentage difference



Note: The error bars show ± two standard errors.
Source: Authors' calculation.

The data can also be used to investigate the impact of COVID-19 on margins and how that impact compares to the 2007-2008 period. Data point to an increase of about 3% in insurance and freight cost and 4% in the cost per kilogramme imported in 2020 than a year ago. This contrasts with 2007-2008, in which costs per kilogramme increased by around 11-13% but margins increased only by 1-6%.

The differences between the two periods are most likely driven by different effects of the crises on the price of imported products relative to the costs of transport and insurance. The average import value per kilogramme, i.e. unit value of imports, soared during the financial crisis, but this did not happen during the pandemic, as can be seen in figure D.1 in the appendix. One possible explanation is a shift towards importing a more expensive product within the same HS 6-digit category (which cannot be accounted for in the trade composition analysis above), which can be driven by income effects (i.e. income decreases possibly leads to fewer cheap imports) or by Alchian-Allen effects (Hummels and Skiba, 2004) – a per-unit transactions cost lowers the relative price of, and raises the relative demand for, high-quality goods.

4. Estimating missing value with gravity modelling

This section presents the model used to fill in missing observations.

4.1. Main model estimates

Following Miao and Fortanier (2017), a gravity model is estimated in order to fill in the missing values for those countries that do not explicitly report CIF-FOB margins:

$$y_{ijkt} = \beta_0 + \beta_1 dist_{ij} + \beta_2 dist_{ij}^2 + \beta_3 gdppc_{it} + \beta_4 gdppc_{jt} + \beta_5 poil_t + \beta_6 yr_t + \beta_7 conti_{ij} + \beta_8 contiguity_{ij} + \beta_9 dist_{ij} \times conti_{ij} + \beta_{10} dist_{ij}^2 \times conti_{ij} + \beta_{10} uvmdn_{kt} + \delta_{k4} + \delta_j + \varepsilon_{ijkt}$$

where y_{ijkt} the log of the CIF-FOB ratio of a specific product *k* imported by country *i* from country *j* at a given year *t*;

$dist_{ij}$ is the log of the geographical distance between countries *i* and *j;*

$uvmdn_{kt}$ the log of median unit value of each HS 6-digit product k in year *t;*

$contiguity_{ij}$ and $conti_{ij}$ the geographical situation of country *i* relative to country *j* – sharing common borders, and in the same continent;

$poil_t$ the log of the average annual price of crude oil (in USD per barrel);

$gdppc_{it}$ and $gdppc_{jt}$the log of GDP per capita of countries *i* and *j;*

yr_t the time trend. Product fixed effect (at HS 4-digit product level) and partner fixed effects are also included in the regression;

The interaction terms of distance and same continent, as well as distance square and same continent are included to capture, if possible, the alternative mode of transports (i.e. by land versus by sea); and

ε_{ijkt} is the error term. Data sources for all variables can be found in table B.1.

Almost all coefficients are significant with the exception of the unit median value for *Electrical energy in thousands of kilowatt-hours* (Table 3).In most cases, the sign is similar to what was estimated in the 2018 update and most signs correspond to *a priori* expectations. Lastly, coefficients are generally close to the previous updates in absolute terms.

Table 3: Coefficient comparison for estimates, 2021 vs 2018 updates

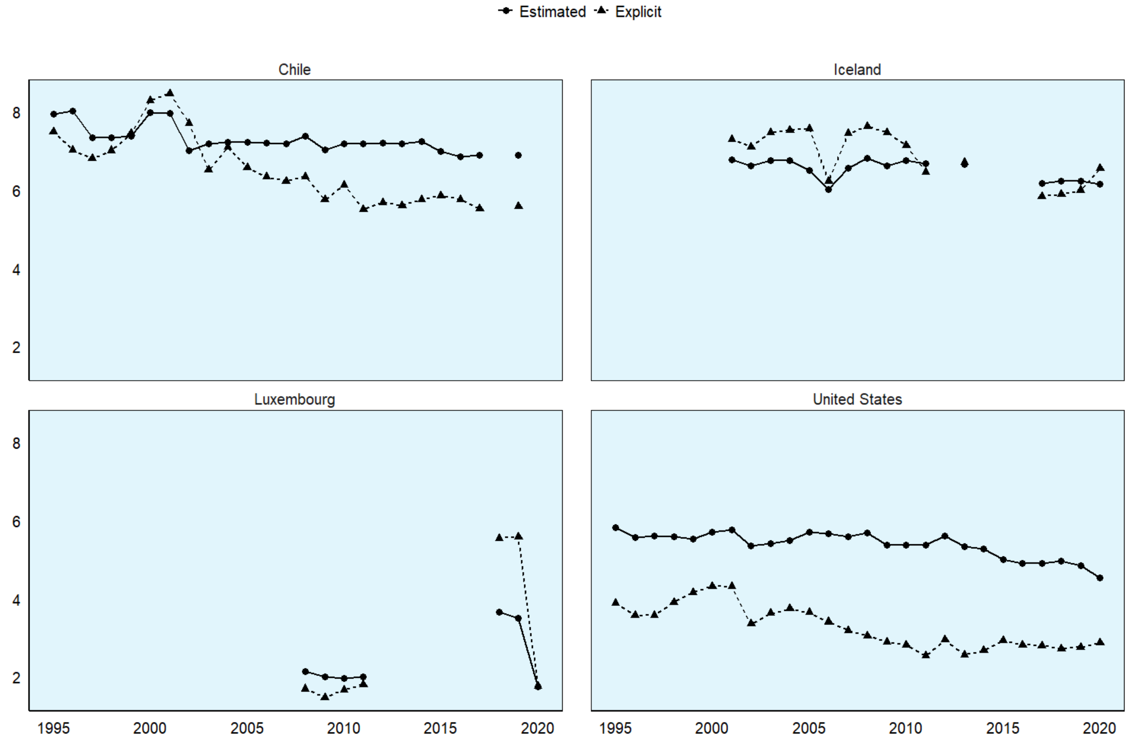
Variable	Coef. 2021	Coef. 2018	Same sign	Absolute Difference	Percent Difference
Intercept	0.6402*** (73.7)	0.1874*** (14.99)	TRUE	0.4528	241.6
Distance	-0.0551*** (-46.86)	-0.0266*** (-9.93)	TRUE	0.0285	107.0
Distance square	0.0035*** (54.85)	0.0021*** (14.68)	TRUE	0.0014	67.6
Contiguity	-0.0140*** (-155.28)	-0.0314*** (-266.86)	TRUE	0.0174	-55.5
Continent	-0.7054*** (-124.01)	-0.4595*** (-36.7)	TRUE	0.2459	53.5
Price of oil	0.0059*** (146.78)	0.0102*** (173.95)	TRUE	0.0043	-41.7
GDP per capita, partner country	-0.0069*** (-104.95)	-0.0095*** (-111.2)	TRUE	0.0026	-27.6
GDP per capita, reporting country	-0.0042*** (-295.2)	-0.0035*** (-160.49)	TRUE	0.0007	20.9
year	-0.0001*** (-37.31)	-0.0005*** (-74.66)	TRUE	0.0004	-73.6
Distance*Continent	0.1683*** (132.01)	0.1235*** (45.49)	TRUE	0.0448	36.2
Distance square*Continent	-0.0099*** (-137.47)	-0.0080*** (-54.22)	TRUE	0.0019	23.9
Median Unit Value Weight in kilograms	0.0003*** (16.9)	-0.0009*** (-42.72)	**FALSE**	0.0012	-133.0
Median Unit Value Number of items	-0.0012*** (-90.27)	-0.0015*** (-96.5)	TRUE	0.0003	-23.1
Median Unit Value Volume in litres	-0.0042*** (-25.7)	-0.0050*** (-29.65)	TRUE	0.0008	-16.9
Median Unit Value Number of pairs	-0.0015*** (-15.27)	-0.0022*** (-20.72)	TRUE	0.0007	-32.7
Median Unit Value Area in square meters	0.0006*** (11.04)	0.0000 (0.63)	FALSE	0.0006	NA
Median Unit Value Volume in cubic meters	-0.0008*** (-14.53)	-0.0008*** (-15.54)	TRUE	0.0000	0.6
Median Unit Value Length in meters	-0.0008*** (-4.99)	-0.0016*** (-10.2)	TRUE	0.0008	-53.1
Median Unit Value Thousand of items	-0.0005*** (-6.9)	-0.0005*** (-7.01)	TRUE	0.0000	7.7
Median Unit Value Number of packages	-0.0017*** (-3.2)	-0.0032*** (-5.8)	TRUE	0.0015	-48.4
Median Unit Value Weight in carats	-0.0031*** (-14.34)	-0.0031*** (-13.13)	TRUE	0.0000	-0.6
Median Unit ValueElectrical energy in thousands of kilowatt-hours	-0.0012 (-1.67)	-0.0019*** (-5.62)	TRUE	0.0007	-39.4
Median Unit Value Dozen of items	-0.0011*** (-41.84)	-0.0004*** (-13.09)	TRUE	0.0007	181.3
No. Observations	14,745,201	8,507,135			
R-Square	0.1139	0.1398			
Root MSE	0.0577	0.0541			

Note: Note: For presentation purposes, the estimates for the HS 4-digit and partner dummies (fixed effects) were omitted. Numbers in parenthesis denote t-values; *** p-value < 0.05.
Source: Authors' calculation.

4.2. In-sample properties of the main model

The main model performs relatively well in sample as it matches explicitly reported data relatively closely, although some specific divergence with the explicit margins can be observed at some point in time (Figure 5). Performance varies also across countries. For example, the United States are consistently over-estimated (as the purpose of the model is to estimate CIF-FOB margin for other countries, we cannot include a country fixed effect). Estimated and explicit margins are much closer for Iceland and Luxembourg, and even seem to be able to capture the sudden increase in margins for Luxembourg in 2018/2019. Chile and countries not shown lie somewhere in-between, having periods in which estimated and explicit margins are reasonably close, and periods in which these two are farther apart.

Figure 5. Explicit and estimated CIF price weighted margins, per cent



Note: Estimated margins are only shown for years in which also explicit data was available. Estimated margins also contain imports which are not covered by the explicit data (i.e. certain products either did not have FOB prices in the explicit data, or their prices were removed in the cleaning process).
Source: UN COMTRADE, US CENSUS, and Authors' calculation.

4.3. Model selection using cross-validation

A refinement compared to previous updates consists of introducing a cross-validation (CV) procedure to this analysis, which is a technique frequently used in the statistical learning literature for model selection (Hastie, Tibshirani, and Friedman, 2016). Two alternative models were used as comparison to the main model estimated in section 4.1. The first one, termed *base* model, is essentially the full model without the partner and HS 4-digit product fixed effects. The second alternative is so-called *intermediate* model and includes only HS 2-digit product fixed effects.

The CV procedure consisted of a loop through all countries that explicitly report CIF-FOB margins. Four countries were never used for validation but always included in the training sample, because without these countries, certain HS4-digit products and partner dummies could not have been estimated. In every iteration, one reporting country was excluded from the sample. Proposed models, namely without partner-product fixed effects, with product fixed effects (at HS 2-digit level), and with partner - product fixed effects (at HS 4-digit level), were estimated on the remaining data, and coefficients were then used to predict the margins for the country left out. The errors between the predicted and the explicitly reported margins were subsequently pulled together to evaluate the performance of each model.

Table 4: Distributional comparison of explicitly reported margins and estimated margins

	Explicit Data	Base Model Estimates	Intermediate Model Estimates	Main Model Estimates
Mean	0.0679	0.0680	0.0679	0.0676
5th percentile	0.0060	0.0402	0.0364	0.0307
25th percentile	0.0290	0.0606	0.0586	0.0561
Median	0.0535	0.0713	0.0693	0.0688
75th percentile	0.0915	0.0791	0.0796	0.0810
95th percentile	0.1855	0.0878	0.0961	0.1009
Skewness	1.3113	-2.5354	-1.5527	-0.6722
Kurtosis	4.5117	18.3002	12.0707	5.7491
RMSE		0.056 (0.004)	0.056 (0.004)	0.055 (0.004)
Median Absolute Error		0.034 (0.002)	0.034 (0.002)	0.033 (0.002)
Median APE		0.536 (0.769)	0.528 (0.738)	0.526 (0.602)

Note: The median was chosen because the distribution of the error is highly skewed and hence the median is likely a more representative measure. Numbers in parenthesis represent cross-validation standard errors calculated by first calculating the error-statistics (e.g. RMSE) for each left out country, CV_{cou}, and then calculating the cross-validation standard error as $SD(CV_{cou})/\sqrt{n}$. Although a formal test for equal performance would have been preferred, an appropriate test could not be found.
Source: Authors' calculation.

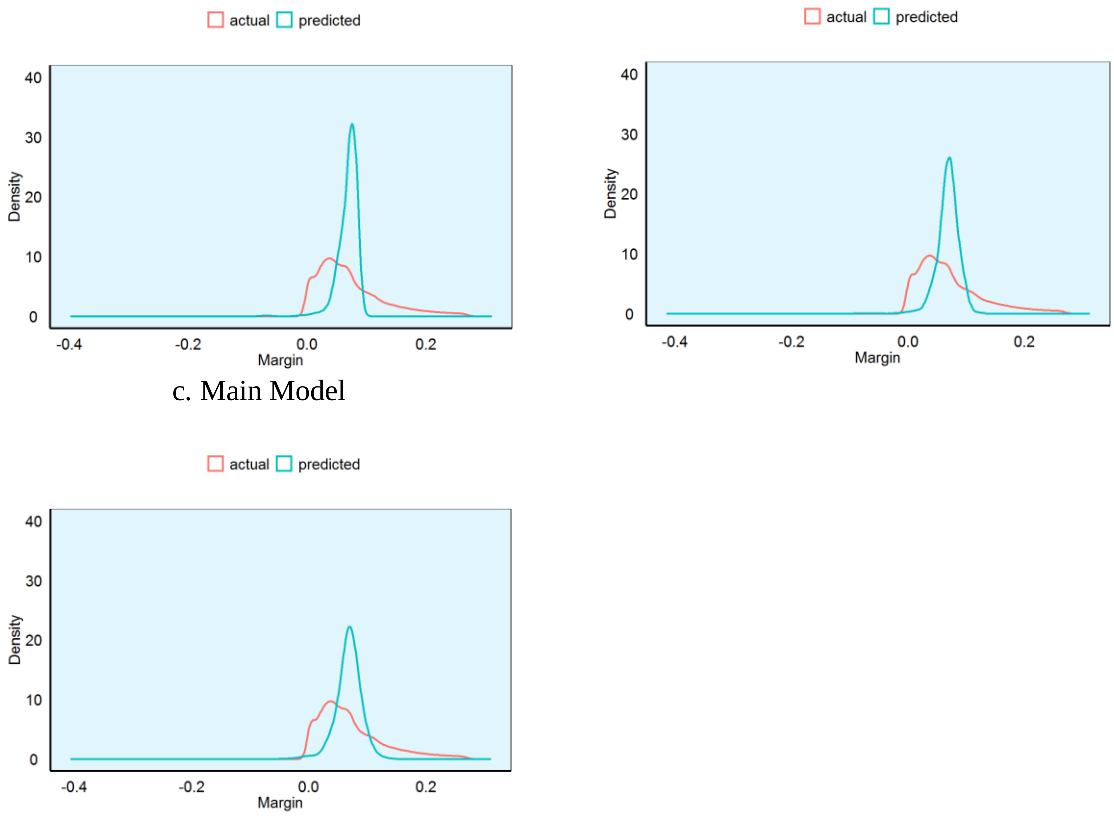
Focusing first on distributional comparisons, none of the models completely manages to capture the right-skewness of the actual/explicitly reported margins (Figure 6). The *base* and *intermediate* model are performing worse than the *main* model though. The latter has a kurtosis and skewness coming closest to that of the distribution of the actual explicitly-reported values (Table 4). Nonetheless, the *main* model performs the best when it comes to replicating the distribution of actual explicitly-reported margins.

Figure 6. Comparison of the estimated distribution of explicitly reported margins and those obtained as out-of-sample estimations in the CV procedure

a. Base Model

b. Intermediate Model

c. Main Model



Source: Authors' calculation.

The three models were compared along two additional metrics.

- Performances measured by the median absolute percentage error (Median APE) on a HS 4-digit level (Figure 7). Outliers are defined as having a median APE above 100%, as the majority of median APEs are around 50%. While the base and intermediate model show many outliers (thirteen and fourteen respectively), the main model had fewer outliers (six). Despite the HS 4-digit product fixed effects, the *main* model still fails to explain HS 8002 (*Tin; waste and scrap)* very well. Since the *main* model showed fewer outliers on a HS 4-digit level than the other two models, it was considered as the most appropriate, despite the outliers for very few HS 4-digit product codes.

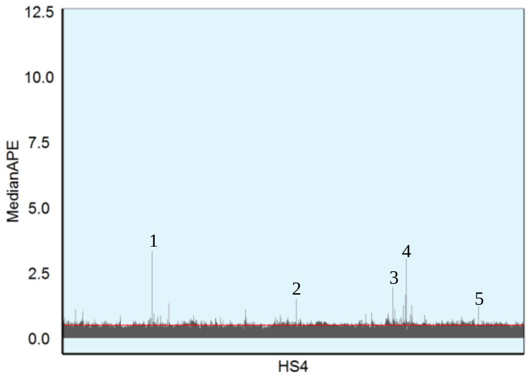
- Performances measured by the median APE on a partner level by taking again the median APE (Figure 8). This time no clear differences exist. The relative performances of the different models vary across partners.

Overall, a change in methodology towards a more parsimonious model is not warranted, as the *main* model managed to replicate the distribution of actual (explicitly reported) margins the best, had fewer outliers on the HS 4-digit product level, and performed best overall when measured by RMSE, median absolute error, and median APE, only marginally though (Table 4). The CV exercise also showed that the use of a more parsimonious model would come at the cost of a worse distributional match.

Finally, the CV exercise points to high uncertainty for estimates within the HS 4-digit codes, such as 0301 (Fish; live), 0302 (Fish; fresh or chilled), 0707 (Cucumbers and gherkins; fresh or chilled), 2619 (Slag, dross), 5103 (Waste of wool or of fine coarse animal hair), and 8002 (Tin; waste and scrap), for which the median APE is greater than 100%, and for partners Burundi, Kenya, Montenegro, South Sudan, Turks and Caicos Island, United Republic of Tanzania, and Uganda.

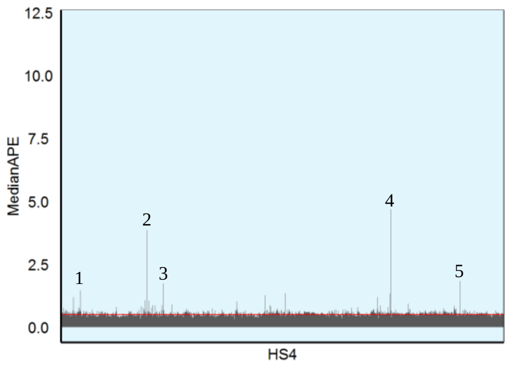
Figure 7. Simulated out-of-sample performance by product (HS 4-digit level) obtained using cross-validation

a. Base Model



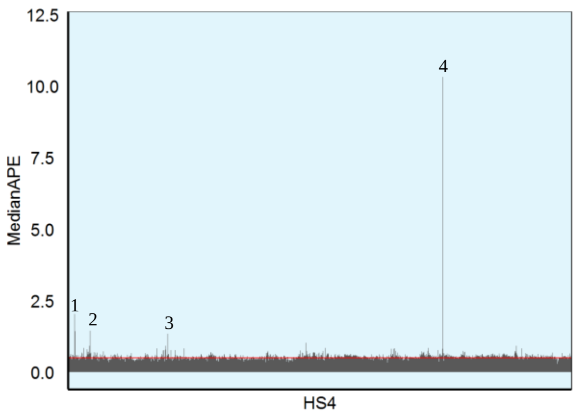
Selected outliers: (1) 2613: Molybdenum ores and concentrates; (2) 5502: Artificial filament tow; (3) 7502: Nickel; unwrought; (4) 8002: Tin; waste and scrap; (5) 8710: Tanks and other armoured fighting vehicles …

b. Intermediate Model



Selected outliers: (1) 0707: Cucumbers and gherkins; fresh and chilled; (2) 2613: Molybdenum ores and concentrates; (3) 2822: Cobalt oxides and hydroxides; commercial cobalt oxides; (4) 8002: Tin; waste and scrap; (5) 8710: Tanks and other armoured fighting vehicles …

c. Main Model

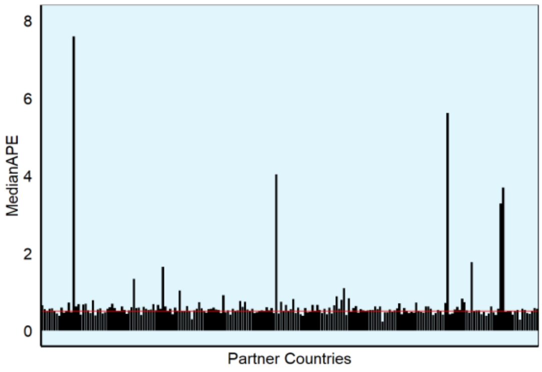


Selected outliers: (1) 0301: Fish; live; (2) 0707: Cucumbers and gherkins; fresh and chilled; (3) 2619: Slag, dross …; (4) 8002: Tin; waste and scrap

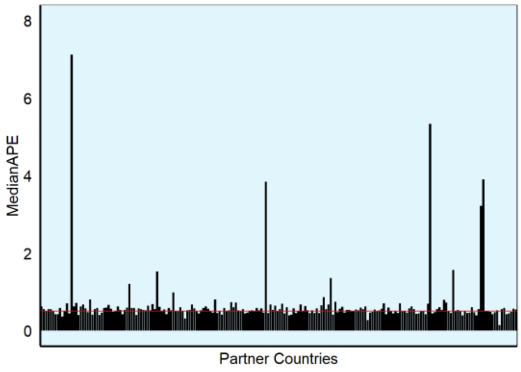
Source: Authors' calculation.

Figure 8. Simulated out-of-sample performance by partner country obtained using cross-validation

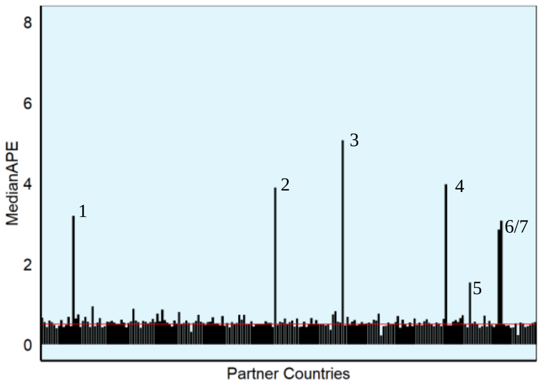
a. Base Model



b. Intermediate Model



c. Main Model



Selected outliers: (1) Burundi (2) Kenya (3) Montenegro (4) South Sudan (5) Turks and Caicos Islands (6) United Republic of Tanzania (7) Uganda

Source: Authors' calculation.

4.4. From estimates to ITIC database

Estimates from the gravity model are combined with the explicit data, aggregated to HS 4-digit level to create the ITIC database. A few interpolations were necessary in order to fit the estimated data to explicitly reported data, and to fill gaps, which are especially present for confidential trade. Estimates for periods in which certain country pairs did not trade a certain good were also derived. A more precise description of the post-processing and interpolations can be found in Miao and Fortanier (2017).

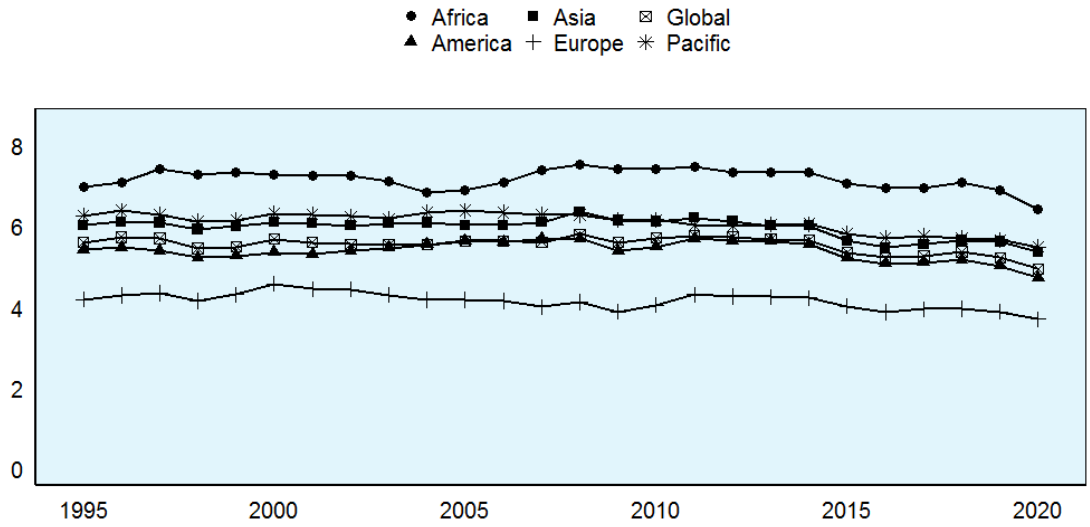
5. Main insights from the database

The detailed information from the ITIC database points to the following observations.

At the global level, the CIF weighted average international transport and insurance margins are at around 5.5% over the period 1995 to 2020. This is lower than the previous update. CIF-FOB weighted average margins were around 5.0% in 2020.

Margins fluctuate over time and across regions (Figure 9). Africa displays the highest margins at all times, at around 7%. This is followed by Asian and Pacific economies, whose margins are very similar. Americas (combining north and south) have the second lowest margins but there is large heterogeneity within American countries: the United States have much lower margins than the American average. Europe, with a large share of its trade with partners in close proximity, is estimated to have the lowest margins, at around 4%. There are considerable variances between European countries too: with Luxembourg and Switzerland having much smaller margins (around 2% most of the time) while Ukraine having much higher margins (around 7% most of the time). Germany lies in the middle with estimated margins around 3.5%. Table 5 shows the variability in the margins of the G20 countries.

Figure 9. CIF weighted average margins per continent and on a global scale confirm a priori expectations about the ordering, estimated, per cent



Source: Authors' own estimation.

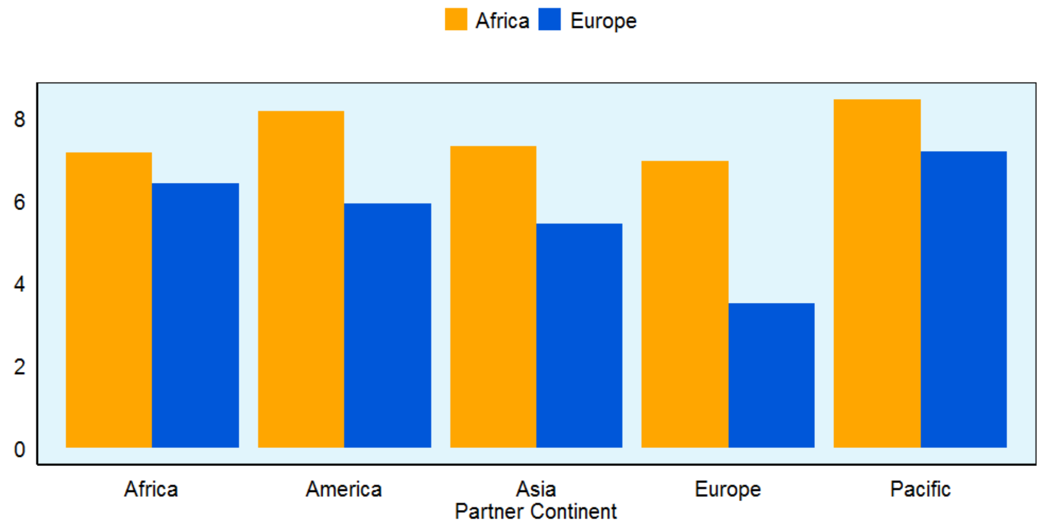
Table 5: Summary statistics of yearly CIF price weighted average estimated margins

Country	1995-2020			2010	2020
	mean	min	max		
Argentina	6.8%	6.3%	7.3%	6.8%	6.7%
Australia	6.0%	5.5%	6.4%	6.1%	5.6%
Brazil	7.2%	6.8%	7.6%	7.3%	7.0%
Canada	5.4%	5.0%	5.7%	5.5%	5.1%
China	6.1%	5.7%	6.6%	6.3%	6.0%
Germany	3.7%	3.2%	4.2%	3.4%	3.4%
France	4.1%	3.5%	4.5%	4.1%	3.6%
United Kingdom	4.5%	3.9%	5.1%	4.2%	4.1%
Indonesia	7.3%	6.8%	8.0%	6.9%	6.9%
India	7.0%	6.6%	7.7%	6.8%	6.8%
Italy	4.6%	4.3%	5.1%	4.7%	4.7%
Japan	6.3%	5.5%	6.6%	6.3%	5.8%
South Korea	6.1%	5.2%	6.6%	6.3%	5.6%
Mexico	6.1%	5.0%	6.7%	6.5%	5.6%
Russia	6.3%	5.9%	7.0%	6.2%	5.9%
Saudi Arabia	6.8%	5.9%	7.1%	6.9%	5.9%
Turkey	6.2%	5.6%	7.0%	6.0%	5.9%
Unites States	5.1%	4.5%	5.5%	5.1%	4.7%
South Africa	6.3%	5.8%	6.8%	6.6%	6.2%

Note: The table displays summary statistics of the yearly CIF price weighted average estimated margins for G20 countries (excluding the European Union). Margins are defined as (CIF-FOB)/CIF.
Source: Authors' estimation.

Intra-European trade has the lowest estimated margins (Figure 10, Table C.1). The average margins of European trade with partners from Africa, America, and Asia are all very similar, varying between 5-7%. European imports from Pacific countries are estimated to have on average almost twice the margins of intra-European trade. The import margins of African countries, on the other hand, seem to be largely independent of the origin. The average estimated margin of African imports from Europe is almost the same as the average estimated margin of European imports from Africa, showing that for transport and insurance costs, estimated asymmetries seem to be very small.

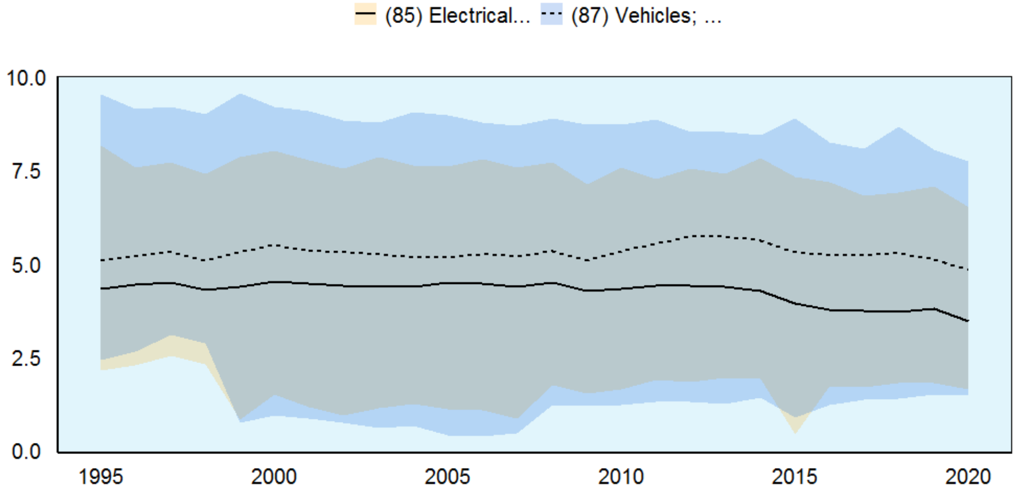
Figure 10. CIF weighted average margins of European and African trade with other regions, estimated, 1995-2020, per cent



Source: Authors’ estimation.

Looking at a more disaggregated level, chapter 87 (Vehicles other than railway, tramway) has a higher CIF weighted average estimated margin than chapter 85 (Electrical, electronic equipment) (Figure 11). This turns out to be generally the case. In around 98% of the time, a country’s CIF weighted average estimated margin is higher for chapter 87 than for chapter 85 in a given year. The difference is only around one percentage point though. Thus, although the transportation cost per unit of goods in chapter 87, which includes cars, is likely a lot higher than the transportation cost per unit of phones, which are included in chapter 85, their margins can be relatively close. The range of margins is a lot wider for chapter 87 than it is for chapter 85.

Figure 11. CIF weighted average margins for electrical, electronic equipment and vehicles other than railway, tramway, and their country average ranges, estimated, per cent



Note: The shaded areas represent the range from the minimum to the maximum CIF weighted average margins on a country level for the corresponding chapter, i.e. in 1995 the country with the minimum CIF weighted margin for (87) Vehicles … had a margin of around 2.5%, while the country with the maximum had a margin around 10%.
Source: Authors' estimation.

6. Conclusions

6.1. Main insights

The OECD ITIC database provides CIF-FOB margins at detailed product level. It helps to understand how trade costs have shaped trade developments, and is an important tool to balance bilateral trade statistics. ITIC data maps the trends in CIF-FOB margins over time and informs on differences in margins across countries and regions. The dataset – which is complete as gaps have been filled by means of a gravity model – can be used as a fully consistent input into structural and longer term analyses of merchandise trade.

The new update for the OECD ITIC database extends the explicit data coverage from original sixteen countries to thirty-three countries, and expands the time series by an additional four years, and now covers 1995-2020. The new estimates show that, at the global level, the CIF weighted international transport and insurance cost has been about 5.5% over the period 1995-2020, slightly lower than earlier estimates. Both the CIF-FOB margin and the cost per kilogramme imported increased in 2020 when compared to 2019, a finding that is robust to corrections for compositional changes.

A newly conducted cross-validation procedure shows that the gravity model with partner-product fixed effects (at HS 4-ditgit product level) outperforms simpler models that do not take these partner and product characteristics into account. The general robustness of the imputation model comes at the price of being less well suited for certain short-term analyses. For instance, the main model fails to fully capture the reported increase in transport and insurance costs in 2020. This is likely due to its linear specification and the economic and health crises which may have altered the structural relationship between economic activity and CIF-FOB margins. It follows that caution is called for when interpreting the modelled data for individual crisis years. The cross-validation procedure has also shown that there is still some scope for improvement to match the variance and right-hand tail of the explicitly reported margins distribution.

6.2. Future Work

The mismatches between estimated and explicitly reported margins that were found are likely due to the inability to control for reporting country fixed effects, and not having any variables that provide enough information on the variances and the trends especially during crisis years. More generally, the model used is more of a long-term model which is already reflected in the linear trend instead of separate year controls. As such, the gravity model used will struggle to pick up short-term developments during crisis periods. The issue of not being able to use reporting country fixed effects could be solved by finding explicit measures that account for these characteristics. However, since most measures of explicit country characteristics are relatively new (such as port quantity and road quality which are available only from 2006 onwards), this would limit the period that ITIC can cover, or introduce a break in the methodology. The model could also be further extended in such a way that also short-term developments could be captured. This could be done by further investigating the actual drivers of margins, especially during crisis periods. Such an analysis was beyond the scope of this paper. Further progress in deriving reliable import prices estimates could in turn improve the quality of CIF-FOB margins.

In addition, there is also scope to examine whether new approaches to modelling CIF-FOB margins, including non-linear models or non-parametric approaches could lead to more precise estimates than gravity modelling, especially for the short term.

Finally, distances that goods travel between countries are not always constant and CIF-FOB margins could depend on other factors. Transport and insurance margins in a country are not only influenced by characteristics of the importer and corresponding exporter, but, potentially, also by the characteristics of every country/region the good is travelling through. The margin for a landlocked country can, for example, suddenly jump from one year to another if one of the surrounding countries through which the goods travel is involved in internal conflicts. Mapping out trade routes and the use of spatio-temporal or network models could help uncover such a behaviour.

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Annex A. CIF-weighted average margins

Table A.1. CIF-weighted average margins, by reporting country

Year	ARG	AUS	BOL	CHL	COL	NZL	PER	PRY	URY	USA	BRA	ECU	ISL	LUX	RWA	SVK	CZE
1995	7.0%	6.7%	10.8%	7.6%	7.4%	7.0%	8.3%	13.8%	7.1%	3.9%							
1996	6.4%	6.6%	10.5%	7.1%	7.0%	6.9%	7.7%		6.9%	3.6%							
1997	5.8%	6.6%	10.2%	6.8%	6.7%	6.7%	7.4%		7.1%	3.6%	5.5%						
1998	5.2%	6.7%	18.0%	7.1%	6.8%	6.8%	7.9%		7.4%	3.9%	5.5%						
1999	5.0%	6.0%	18.9%	7.5%	6.7%	6.0%	7.5%		6.1%	4.2%	5.1%						
2000	5.2%	6.1%	21.0%	8.3%	6.6%	5.8%	7.4%		4.9%	4.3%	5.0%	8.1%					
2001	5.4%	6.1%		8.7%	6.9%	6.3%	7.9%		5.5%	4.3%	5.1%	7.7%	7.4%				
2002	5.7%	5.3%		7.7%	6.9%	5.9%	7.5%		4.8%	3.3%	4.6%	7.0%	7.3%				
2003	4.8%	5.4%		6.4%	6.2%	6.0%	7.0%		4.2%	3.6%	4.7%	6.5%	7.3%				
2004	4.5%	5.8%		7.0%	6.8%	6.0%	7.5%		4.3%	3.7%	4.5%	6.9%	7.4%				
2005	4.4%	5.6%		6.5%	6.5%	6.1%	7.3%		4.3%	3.6%	4.6%	6.5%	7.4%				
2006	4.0%	5.2%		6.2%	6.0%	5.9%	6.8%		4.1%	3.4%	3.8%	6.2%	6.6%				
2007	6.9%	4.6%		6.1%	6.0%	5.6%	7.2%		5.0%	3.2%	4.3%	6.5%	7.4%				
2008		4.6%		6.2%		5.7%	7.0%	5.6%		3.0%	4.9%		7.6%	1.5%			
2009		4.0%		5.7%		5.1%	6.1%	6.1%		2.9%	4.3%		7.6%	1.4%			
2010		4.2%		6.1%		5.4%	6.3%	6.2%		2.8%	5.0%		7.2%	1.5%	2.7%	3.8%	
2011		3.9%	6.6%	5.5%		4.9%	5.3%	6.4%		2.5%	4.4%		6.5%	1.8%	2.8%	2.3%	5.0%
2012		4.0%	6.4%	5.6%		4.9%	5.4%	6.7%		2.9%	4.3%				3.6%	2.6%	
2013		4.1%	6.2%	5.5%		4.9%	5.2%	6.8%		2.6%	4.2%		6.8%		2.5%	2.3%	4.9%
2014	4.1%	4.0%	6.4%	5.8%		4.8%	5.2%	6.9%		2.7%	4.1%				2.4%	3.7%	
2015	4.1%	4.0%	6.5%	5.9%		4.9%	5.3%	7.1%		3.0%	4.1%				3.2%	3.6%	
2016	4.0%	3.6%	6.6%	5.8%		4.5%	5.0%			2.9%	4.1%				4.3%		
2017	4.2%	3.4%	6.7%	5.6%	4.6%	4.4%	4.9%	6.9%	5.6%	2.8%	4.1%	4.8%	5.8%		14.1%		4.9%
2018	4.4%	3.6%	6.5%		4.4%		4.7%	6.6%	5.5%	2.8%		4.5%	5.9%	5.9%	14.4%	2.6%	4.9%
2019	4.4%	3.4%	6.8%	5.6%	4.5%	4.1%	5.1%		5.2%	2.8%			6.0%	5.9%	12.6%	2.6%	4.9%
2020	4.7%	4.2%	7.0%		5.2%	5.1%			5.5%	2.9%	4.5%		6.6%	1.8%		2.9%	4.9%

Year	TUR	KIR	AGO	MDG	MUS	CPV	DOM	HND	MOZ	NIC	SRB	STP	MDV	PHL	SEN	NAM	% of WRD TRD
1995																	8.2%
1996																	7.7%
1997																	8.9%
1998																	8.9%
1999																	8.9%
2000																	9.3%
2001																	9.4%
2002																	16.5%
2003																	16.4%
2004																	15.3%
2005																	16.3%
2006																	15.1%
2007																	15.5%
2008																	14.4%
2009																	13.7%
2010																	14.5%
2011																	15.0%
2012																	10.6%
2013	5.1%																15.8%
2014	5.1%	8.9%															16.0%
2015	4.2%	8.2%	7.7%														16.3%
2016	4.5%		7.0%	9.4%	6.0%												15.1%
2017	5.1%		7.2%	8.5%		8.5%	7.1%	3.6%	10.2%	6.9%	6.2%	13.0%					18.4%
2018	5.2%			7.5%	6.0%				10.0%		2.7%	12.9%	8.0%	5.2%	7.8%		16.3%
2019					6.0%						3.0%					10.5%	16.0%
2020	4.0%				7.1%						3.0%						19.7%

Note: CIF-FOB margins, defined as (CIF-FOB)/CIF were first calculated on a reporter-partner-year-HS 6-digit level and then aggregated to a reporter-year level using a CIF-weighted average. Observations with the margins above 95% percentile or below zero were discarded.
The CIF-FOB margin for Rwanda saw a sudden jump from 4.3% in 2016 to 14.1% in 2017 and remain high in the subsequent two years. The increase in transport and insurance costs is not particularly driven by any specific product or product group, nor is explained by the sudden fluctuations in exchange rate or a political event. As Rwanda has very small number of observations in imports, relative to other thirty-three countries, these data are included in the modelling without having a big influence on the final estimation.

Annex B. List of variables used in the model

Table B.1. List of variables used in the model and their sources

Variable	Description	Source
$distance_{ij}$	Weighted distance between countries i and j	CEPII Gravity Data Set (Head, Mayer and Ries, 2010[1])
$gdppc_{it}$ / $gdppc_{jt}$	GDP per Capita (US $)	WB WDI
$price\ of\ oil_t$	West Texas Intermediate Crude Oil Price	FRED St. Louis FED
$year_t$	Year (time trend)	
$continent_{ij}$	Dummy (1 if continent of countries is the same)	Derived from CEPII Gravity Data (Head, Mayer and Ries, 2010[1])
$contiguity_{ij}$	Dummy (1 if countries share common border)	CEPII Gravity Data Set (Head, Mayer and Ries, 2010[1])
$median\ unit\ value_{kut}$	Median unit value in year t, HS6 code k and unit u	Calculated using UN COMTRADE data
$distance_{ij}$	HS2 fixed effects	UN COMTRADE
$gdppc_{it}$ / $gdppc_{jt}$	HS4 fixed effects	UN COMTRADE
$price\ of\ oil_t$	Partner fixed effects	UN COMTRADE

Annex C. CIF weighted estimated margins per region and region partner

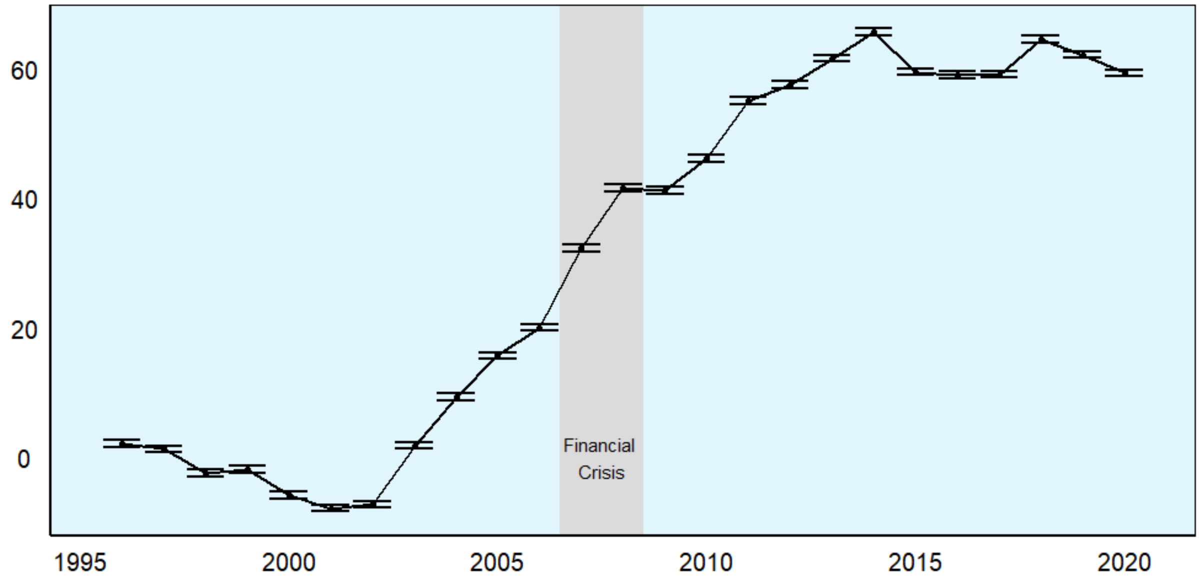
Table C.1. CIF weighted average margins per regions and region partner

	Africa	America	Asia	Europe	Pacific
Africa	7.2%	8.2%	7.3%	6.9%	8.4%
America	6.6%	5.2%	5.7%	5.4%	6.1%
Asia	7.2%	7.2%	5.6%	5.8%	8.3%
Europe	6.4%	5.9%	5.4%	3.5%	7.2%
Pacific	7.3%	6.7%	5.6%	6.5%	6.1%

Note: Margins correspond to predicted margins using the gravity model. Negative estimates were removed. Margins were aggregated using a CIF weighted average.

Annex D. Value of imported goods per kilogramme

Figure D.1. Value of goods imported per kilogramme, FOB valuation, with respect to 1995 levels, percentage difference



Note: Values are corrected using the procedure explained in section 3.2. The error bars show ± two standard errors. Only explicitly reporting countries were used for the calculations since other countries do not report imports in FOB valuation.
Source: Authors' calculations.