Title: QDR methodology: understanding bilateral trade flows in the European Union

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Abstract:

Trade asymmetry has been a well-known fact and there are extensive literature and reports about the causes for those asymmetries. There is also a recognised effort made by trade statisticians for mitigate trade asymmetry over time. Notwithstanding the positive achievements that have been made so far, to build an Inter-Country Supply, Use and Input-Output tables (IC-SUIOT) we more than low trade asymmetry: we need no trade asymmetry at all. The European Statistical System (ESS) has an extensive and rich amount of trade data and a lot of resources are devoted to measure trade flows. Nevertheless, the customs union of the EU adds another challenge regarding trade in goods statistics: Member-States declare imports/exports for customs or tax purposes without this Member State having acquired ownership of the goods, i.e. declare quasi-transit as well. While relevant for physical flow of trade, quasi-transit and re-exports distort the geographical economic relationship among Member-States and therefore they should be identified and taken into account in the framework of IC-SUIOT. QDR methodology was developed in order to address the specificities of trade in goods in EU by providing a way to estimate consolidated trade flows, i.e. solving trade asymmetries, between two countries by three types of trade: quasi-transit (Q), domestic (D) and re-export (R). For quasi-transit and re-exports the intermediary country between that takes part of the physical flow between origin and destination is also identified. QDR methodology was used in FIGARO project and it revealed very useful for identifying relevant trade relationships within countries.

JEL codes: C61, C82, F14, F15

Keywords: supply and use tables; international trade; trade asymmetries

[1] Eurostat, Unit C5 - Integrated global accounts and Balance of Payments

Introduction

QDR methodology combines available trade in goods and national accounts data into a global and consolidated trade data set broken down in three categories: quasi-transit (Q), domestic trade (D) and re-exports (R). It was specifically developed for the FIGARO project - Full International and Global Accounts for Research in Input-Output Analysis, a project that aims to produce an experimental EU-Inter Country Supply, Use and Input-Output Tables (EU-IC-SUIOT). From the experience and knowledge gained during FIGARO, the necessary capacity was for yearly production of EU-IC-SUIOTs and the production of a time series of EU-IC-SUIOTs from 2010 to 2015 (IOTs 2010-2015, SUTs 2010 and 2015) was developed. The project started in October 2015 and has finished in December 2017.

QDR methodology is a crucial part of FIGARO since it provides a balanced trade view of exports originated in the reference country which is a fundamental set of information to connect use tables of domestic inputs, the core part of an ICIO.

This paper will highlight the most important aspects of the QDR methodology and concrete examples will be shown for better understanding of its potential but also its limitations and assumptions.

Methodology overview

Figure 1 shows the complete production system for estimating consolidated trade in goods broken down into quasi-transit, domestic and re-exports, put in place during FIGARO. It is compose of 5 main steps and 7 main data sets.

Step 1 assures that all data sets received from trade in goods Unit are compliant with the FIGARO code lists, i.e. variable labels, code lists, unit measured, etc. are harmonized. Step 2 combines all data into three data sets ITGS_RAW, which contains trade in goods statistics from COMEXT by country of consignment (country from which goods were dispatched) and country of origin (country where the good is originated) for imports; ITGS_CONSIGN, a simple aggregation of ITGS_RAW by country of consignment and ITGS_UN, from the UN COMTRADE database.

All data sets are valued in thousands of euros and have ISO-country 2-digit codes for geographical entities and Harmonised Commodity Description and Coding System (known as Harmonised System, or HS) developed and maintained by the World Customs Organisation.

The first two steps do not change or estimate any data whatsoever. Steps 3, 4 and 5, however, imply estimation, imputations and assumptions therefore they will be explained more in details in the next sections.

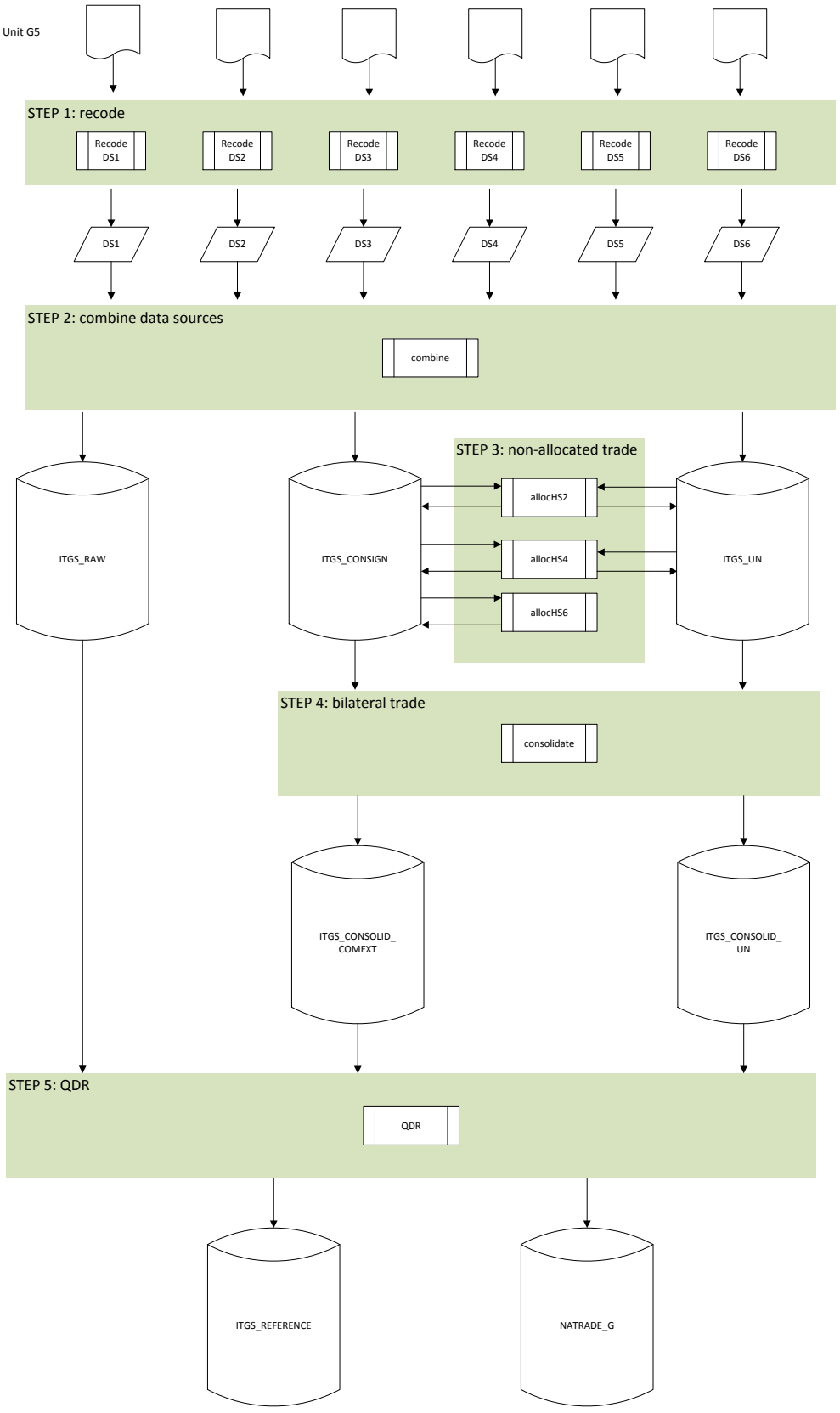


Figure 1: Trade in goods production system in FIGARO

Non-allocated trade estimation

There are many reasons for trade asymmetries. One of the reasons is linked to confidentiality by only one of the two partners. In fact, we can extend this cause to a more general one: whenever one of the two partners do not fully specified which product and / or trading partner, there will be a trade asymmetry.

In order to mitigate this cause of asymmetry, a non-allocate trade estimation procedure was developed. We start by defining "**fully specified trade**" as the trade for which product at HS6 level, reporting country and trade partner are fully specified. For EU imports, where there should be information on both country of consignment and country of origin, if the country of origin is not specified it is assumed that country of origin is the same as country of consignment. This assumption can create bias in the final trade geographical distribution. However, the QDR methodology includes a bias correction procedure which will be explained later on.

Methodology

A trade flow ($F_{i\to j}$) is the value of goods traded between a country i with another country j. In general, for the same trade flow there are two estimates of its value, the exports declared by country i (X_i) and the imports declared by country j (M_j). Whenever $X_i \neq M_j$, there is a trade asymmetry. We are assuming that bot exports and imports are valued in FOB, i.e. the value of imports that are normally declared in CIF was already converted to FOB. For each trade flow the value of trade asymmetry is computed as:

$$A_{i\to j} = M_j - X_i \qquad (1)$$

If $A_{i\to j}$ is significantly big and positive, it means that the trade partner is declaring a much bigger value than the exporting country. This information can be useful to allocate non-specified exports in the sense that it points to a particular specified product / partner for which there's a significant lack of exports.

In order to mitigate trade asymmetries by using non-specified trade, the following procedure was implemented.

For each HS6 product:

1. Compute $A_{i\to j}$ for each trade flow;
2. Define an outlier threshold as $\mathrm{h} = max\big(0, q_3 + 1.5(q_3 - q_1)\big)$ where q_1 and q_3 are the first and third quartile of $A_{i\to j}$;
3. Define significant positive asymmetry Δ as:

$$\Delta = \begin{cases} A_{i\to j} & , \quad A_{i\to j} > \mathrm{h} \\ 0 & , \quad otherwise \end{cases}$$

4. Distribute un-specified trade proportionally to Δ with the constraint that the new imputed value doesn't exceed $A_{i\to j}$, i.e. doesn't exceed the mirror data. Imputation of non-specified trade is done sequentially updating after each step exports and imports including the imputed values and re-computing $A_{i\to j}$ and Δ. The imputation sequence is the following:
    a. Non-specified EU partner;
    b. Non-specified extra-EU partner;
    c. Non-specified product in EU;
    d. Non-specified product in extra-EU;

e. Non-specified partner where it's not specified if it belongs to EU or extra-EU.

As a result of the non-allocated trade procedure there will be additional (estimated) fully specified trade that will be added to the fully specified trade records provided by countries, dully marked as been estimated by Eurostat. This allows to fully tracing back how much of an original flow was reported by countries and how much was imputed by this procedure.

Results

The non-allocated trade procedure was able to allocate 163 B€ of exports which represents 4.4% of the fully specified exports. Therefore, the value of fully specified exports increased in almost every country. The increase of exports ranged from 32% in Malta, followed by the Netherlands with 13%, to 0% in Poland, Slovenia, Slovakia and Croatia (Figure 2).

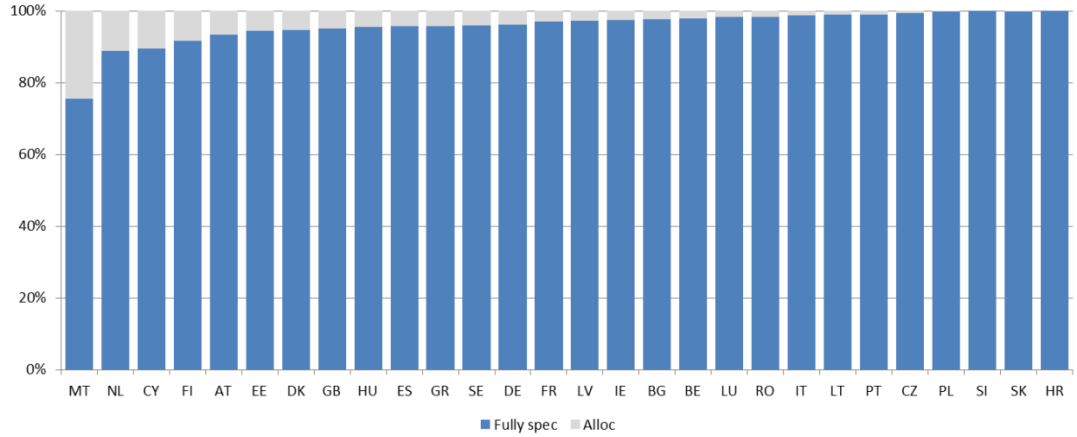


Figure 2: Fully specified trade + allocated trade, by country

By product, the increase of fully specified exports ranged from 18% for "electricity, gas, steam and air-conditioning" (CPA_D35) and "mining and quarrying" (CPA_B) to 2% for "fish and other fishing products; aquaculture products; support services to fishing" (CPA_A03), "electrical equipment" (CPA_C27), "furniture; other manufactured goods" (CPA_C31_32), "wood and of products of wood and cork, except furniture; articles of straw and plaiting materials" (CPA_C16) and "textiles, wearing apparel and leather products" (CPA_C13T15) (Figure 3).

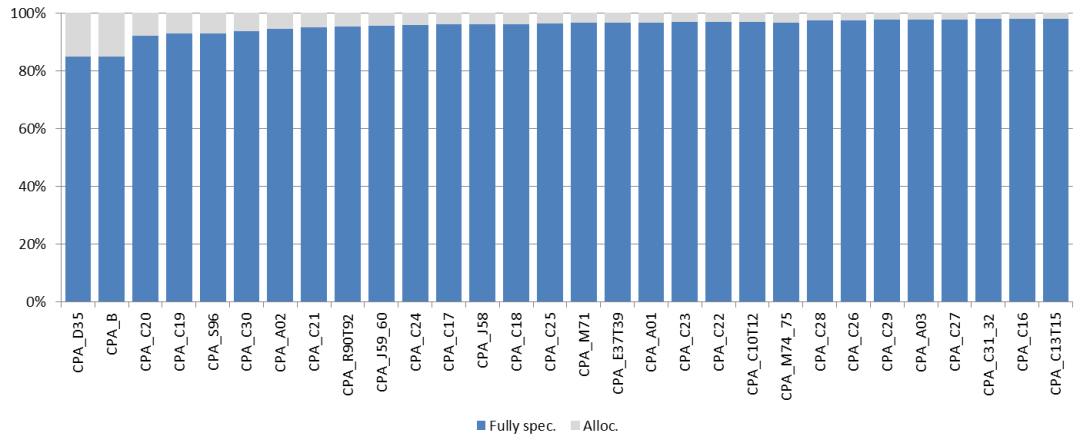


Figure 3: Fully specified trade + allocated trade, by product

Trade asymmetry has also reduced by the non-allocated trade procedure. Trade asymmetry as measured by the Weighted Average Percentage Error (WAPE) between exports and mirror exports, both valued in FOB, has reduced on average 4% both by country and by product.

	Before	After
by Country	[12.3 , 39.8]	[10.5 , 33.2]
by Product	[16.5 , 32.0]	[13.1 , 26.6]

Table 1: WAPE between exports and mirror exports before and after applying the non-allocated trade procedure

Bilateral trade

The bilateral trade procedure will reconcile exports and mirror exports which are supposed to be measuring the same trade flow. The general principle behind the consolidation procedure is that if there are two estimates for the same phenomena, use both of them but to take into account how reliable both are.

CIF/FOB

Exports should have the same valuation, i.e. should be expressed in FOB values. To transformed mirror exports, valued in CIF into FOB, estimates at HS4 product level provided by the OECD were used. The same HS4/partner CIF/FOB ratio was used to every HS6 nested within that HS4 more aggregated product. Whenever a specific CIF/FOB ratio was not available, it was imputed using the most detailed information available, e.g. if a particular partner was missing, then the median ratio of similar partners was used, if the HS4 product was not available, then the HS2 product was used, etc.

Methodology

Let X_{ij} be the exports valued in FOB of a certain good from country i to country j, reported by country i and M_{ij} the "mirror exports", i.e. the imports value in FOB reported by country j from country i. An asymmetry exists whenever $X_{ij} \neq M_{ji}$ which in practice is very likely to be the case, i.e. an asymmetry exists whenever there are two different values for a single flow. The relative asymmetry of that flow is computed by:

$$A_{ij} = \frac{|X_{ij} - M_{ji}|}{|X_{ij}| + |M_{ij}|} \quad (2)$$

Let $\mathbf{A} = [A_{ij}]$ be a matrix where each cell is the relative asymmetry between country i (row) and country j (column) for a particular good. The median by row :

$$\theta_i = median(A_{ik}), k = 1, \dots, n \quad (3)$$

can be seen as an indicator of how accurate country i is when reports exports of that good, measured by its trading partners. Similarly,

$$\phi_j = median(A_{kj}), k = 1, \dots, n \quad (4)$$

can be seen as an indicator of how accurate country j is when reports imports of that good, measured by its trading partners. For a particular trade between two countries, in the absence of any other information about data quality, it is reasonable to assume that the consolidated trade is closer to the exports value if the exporting country has a low θ_i as compared to ϕ_j from the importing country, i.e. the more accurate data is, the more likely is to be true. We define then "**trade flow**" as the weighted average between exports and mirror exports, with weights proportional to data accuracy (as measured by trading partners), i.e. with weights θ_i^{-1} and ϕ_j^{-1}.

$$\left[\left(\frac{1}{\theta_i}\right) X_{ij} + \left(\frac{1}{\phi_j}\right) M_{ji}\right] \Big/ \left(\frac{1}{\theta_i} + \frac{1}{\phi_j}\right) \quad (5)$$

which can be simplified to the following single flow equation:

$$T_{ij} = \frac{\phi_j \cdot X_{ij} + \theta_i \cdot M_{ji}}{\theta_i + \phi_j} \quad (6)$$

When there is just one estimate for a particular flow, e.g. only exports was reported, then the consolidated trade flow equals that estimate.

The bilateral trade procedure is applied to ITGS_CONSIGN and ITGS_UN, originating the consolidated view of trade from COMEXT and from UN COMTRADE.

Results

According to COMEXT, exports from EU countries are valued in 3891 billion euros. However, mirror exports account for 3568 billion euros. After consolidating trade data from COMEXT, the final value of exports from EU was 3840, i.e. the consolidated value is closer to the value of exports than to mirror exports. Equation (6) can be simplified in

$$FLOW = \theta \cdot XFOB + (1 - \theta) \cdot MFOB \quad (7)$$

so θ measure how close the consolidated flow is from exports. From equation (7) we can derive the value of θ:

$$\theta = \frac{FLOW - MFOB}{XFOB - MFOB} = \frac{3840 - 3568}{3894 - 3568} = 0.834 \qquad (8)$$

The total consolidated exports is a weighted average between exports, with weight 83% and mirror imports with weight 17%. Depending on the product and country θ can vary significantly, in particular for "coke and refined petroleum products" and "electricity, gas, steam and air-conditioning".

Country	Product	theta
CY	Coke and refined petroleum products	100%
FI	Electricity, gas, steam and air-conditioning	86%
DK	Electricity, gas, steam and air-conditioning	82%
SE	Electricity, gas, steam and air-conditioning	78%
FR	Electricity, gas, steam and air-conditioning	76%
…	…	…
LU	Electricity, gas, steam and air-conditioning	24%
LV	Coke and refined petroleum products	21%
LU	Electricity, gas, steam and air-conditioning	18%
LU	Electricity, gas, steam and air-conditioning	17%
SK	Electricity, gas, steam and air-conditioning	14%

Table 2: Top 5 highest and lowest shares of exports in consolidated exports by country and product

QDR

The QDR methodology uses as inputs the consolidated view of trade derived from COMEXT (which follows the community principle for EU countries), the consolidated view of trade from UN (which for EU countries follows in principle[2] the national principle of trade), trade margins from the supply table (T1500) and exports in use tables of total inputs domestic inputs (T1611) and of imported inputs (T1612) for the reference year or the year closer to the reference year. With these inputs, the consolidated view of trade according to the community principle will be broken down in how much of a gross flow is quasi-transit (Q), how much is domestic (D) and how much is a re-export (R), which in turn are split into the value of the good (G) and the value of the margin associated to that re-export (M).

Methodology

For every combination of EU country / HS6 product, let

- X_c be the (gross) exports according to the **community principle**;
- X_N be the (gross) exports according to the **national principle** ;
- X_D be the **domestic component of gross exports**;

[2] Although the UN COMTRADE guidelines specifically request the national principle, some Member States for some products are not able to provide data according to the requested principle, in particular, Member States that are not able to provide in ITGS both countries of consignment and origin. In such cases the data reported follows the community principle. So, UN COMTRADE is mostly according to the national principle.

- X_R be the **re-exports component of gross exports**;
- X_Q be the **quasi-transit component of gross exports**.

Let as well M represent mirror exports counterpart of each indicator mentioned above, i.e. M_c, M_N, M_D, M_R and M_Q.

What differentiates the community principle from the national principle is the fact that the later contains quasi-transit. Therefore, the estimator of X_Q is given by:

$$\hat{X}_Q = X_C - X_N \quad (9)$$

The main source of information about the domestic component of trade is provided by the partner country when it declares that the country of origin is the same as the country of consignment, i.e. a country reports that it has imported a good from a country which happens to be the origin country for that good. Then, the estimator for the domestic component of trade is given by:

$$\hat{X}_D = \frac{M_D}{M_C} X_C \quad (10)$$

The estimator of re-exports is taken as the difference between exports according to the national principle and the domestic component of exports, i.e.

$$\hat{X}_R = X_N - \hat{X}_D = X_N - \frac{M_D}{M_C} X_C \quad (11)$$

Consistency between data sources

Since there two different data sources providing information for the indicators described above, in particular, X_N is taken from UN COMTRADE while all other indicators are provided by COMEXT, there might be cases for which both data sources can provide inconsistent figures which will lead to negative estimates of trade. As such, the first thing to do is to identify and correct data inconsistencies.

Inconsistent data can produce negative estimates for $\hat{X}_Q$ and $\hat{X}_R$ ($\hat{X}_D$ is always positive). Solving

$$\begin{cases} \hat{X}_Q > 0 \\ \hat{X}_R > 0 \end{cases} \quad (12)$$

we get the following constraint for:

$$\frac{M_D}{M_C} X_C \leq X_N \leq X_C \quad (13)$$

This means that as long as exports according to the national principal are equal or bigger than the domestic component of gross exports and equal or smaller than gross exports according to the

community principle, the above estimates will be consistent. In fact, exports according to the national principle will be equal to domestic component if re-exports are 0 and it will be equal to exports according to the community principle if quasi-transit is 0.

Whenever an inconsistency was identified gross exports according to the national principle was set to the lower or upper limit defined by equation (13).

Correction of bias in domestic estimates

Estimates of domestic trade flow are based on the information of country of consignment / country of origin provided by the partner country. Unfortunately, not all countries provide this information. Taking into account that in the absence of country of origin, the most reasonable and practical estimate is to assume that origin is the same as consignment, the result is that the estimate of domestic part of the trade flow is (upward) biased.
To correct the upward bias of domestic component of trade flow, National Accounts data is used to calibrate the initial estimates of domestic component. **Use table of domestic inputs** (T1611) provide information of exports that were produced in a country therefore the ratio exports domestically produced and total exports (T1611 / T1610) is an estimate of the share of domestic exports on total exports.

Products in use table are classified according to the CPA classification and at a more aggregated level than HS 6 digit. Let d_i be first and preliminary estimate of domestic trade of HS 6 digit product, where i refers to all HS products within each CPA and d the domestic exports ratio taken from National Accounts.

Then, d_i were calibrated using the RAS procedure, where initial matrix has two columns (domestic / re-exports) and as many rows has the number of HS 6 digit products within each CPA. Preliminary estimates are then changed by the RAS procedure so that the totals by column equals d and totals by row equals the estimated exports from ITGS.

Quasi-transit and re-export partners

Partners are taken from the distribution of original imports for which country of origin is different from country of consignment. Quasi-transit, by definition, applies only when destination and consignment countries are in EU and country of origin is outside EU. Re-exports apply more generally. When country of origin is the same as country of destination there is a re-import. Cases of re-imports were not taken into account due to the very small value of that trade.

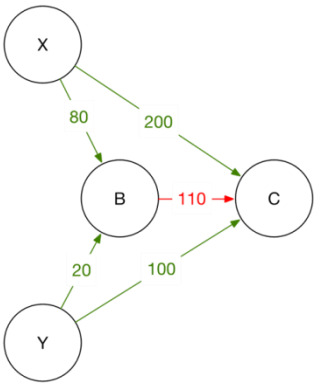
Triangular trade and re-export margins

The final step of the QDR methodology is to take into account the gross trade flow that was split into quasi-transit, domestic and re-exports, to take as well as country of origin in the case of quasi-transit and re-export and generate the corresponding trade flows by category.

The way triangular trade, i.e. when a country of origin ships the good to a country of consignment which is then shipped to a country of destination is better explained with an example.

Let's assume that Country X and Country Y export one type of good, directly, to Country C, with the value of 200€ and 100€, respectively. Let's assume as well that Country B buys 80€ of the same type of good to Country X and 20€ from Country Y, adds a re-export margin of 10% and re-export it to Country C at a value of 88€ + 22€ = 110€.

Figure 4: Hypothetical scenario of triangular trade



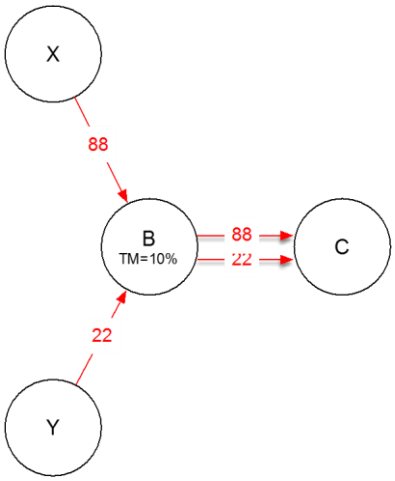
TRADE_TYPE	ORIGIN	CONSIGN	DESTIN	OBS_VALUE
?	X	X	C	200
?	Y	Y	C	100
?	X	X	B	80
?	Y	Y	C	20
?	X	B	C	88
?	Y	B	C	22
				510

The table presented in Figure 4 presents the information that is usually available. Re-exports are marked in red and usually reported by the country of destination (Country C) which declared to have imported from Country B but the good comes from different countries of origin (Countries X and Y).

The first assumption one needs to make is that the value paid by Country C encapsulates the value of the good paid by Country B and a re-export margin. Another assumption that needs to be made due to lack of data is that the trade margins for the re-export service is similar independently of the country of origin, i.e. in this case the same margin of 10% both for Country X and Country Y.

Under these assumptions, then it is possible to split the re-export value of 110€ by country of origin, as shown in

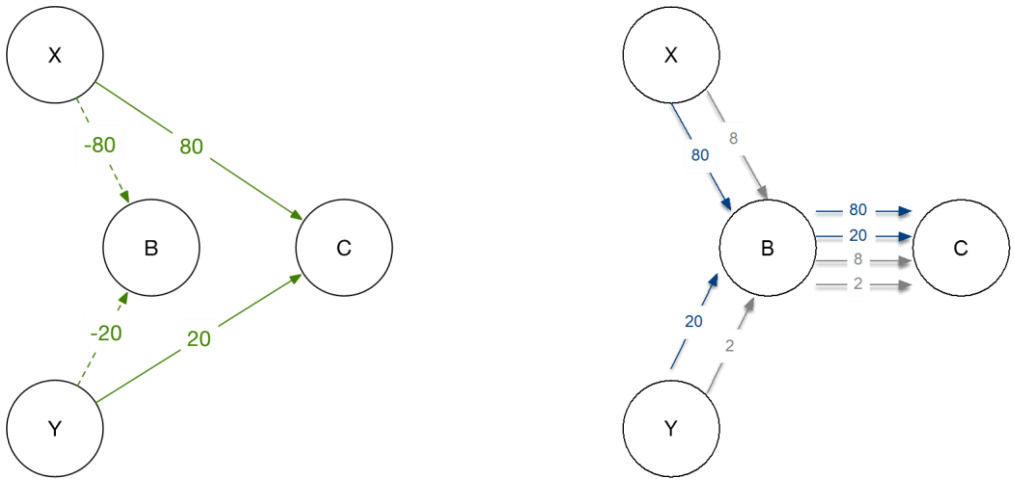
Figure 5: Breaking down the value of re-exports



TRADE_TYPE	ORIGIN	CONSIGN	DESTIN	OBS_VALUE
?	X	B	C	88
?	Y	B	C	22
				110

Combining all these info, one can understand the full amount of transactions occurred, as shown in Figure 6. The value that Country B imports from Countries X and Y for the sole purpose of re-exporting them, i.e. the 80€ from Country X and 20€ from Country Y, can now be connected directly between origin and final destination. This is made by simply imputing the 80€ and 20€ values between origin and destination while removing those same values between origin and country of consignment (represented as negative flows).

Figure 6: Complete set of transactions occurred



Transactions presented in Figure 6 are presented in

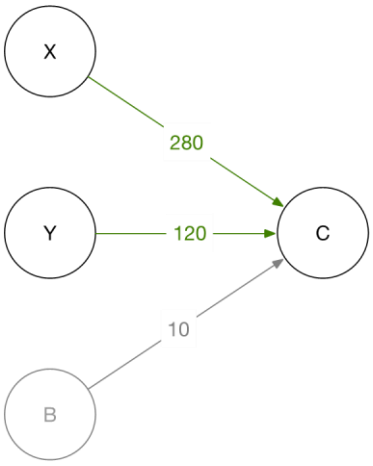
Table 3: Complete set of transactions occurred in tabular form

TRADE_TYPE	ORIGIN	CONSIGN	DESTIN	OBS_VALUE
D	X	X	C	200
D	Y	Y	C	100
D	X	X	B	80
D	Y	Y	C	20
M	X	B	C	8
M	Y	B	C	2
R	X	B	C	80
R	Y	B	C	20
D	X	X	C	80
D	Y	Y	C	20
D	X	X	B	-80
D	Y	Y	B	-20
				510

As presented in Table 3 by definition if the country of origin and consignment are the same, it means a direct flow, i.e. a domestic type of trade. The only exception is for margins where it is useful to record the full path of trade, as long we acknowledge that for trade margins it is the country of consignment who receives it. By aggregating all records of Table 3 we end up with the relevant information we were looking, presented in Table 6: Country X exports 280€ that end up in Country C, Country Y exports 120€ that end up in Country C, and that's the full value of goods involved. However, since Country B was involved in some transactions as a re-exporting country, it received 10€, paid by Country B which used the re-exporting service.

In addition, all triangular trade transactions and respective countries involved are kept, so it is also possible to reconstruct the original transactions. A final remark: the amount of triangular trade plus the trade of interest equals the initial trade totals. As such, this method can be seen as well as a way to remove from the total (raw) amount of trade, the amount that was double counted.

Figure 7: Trade transactions of interest



TRADE_TYPE	ORIGIN	CONSIGN	DESTIN	OBS_VALUE
D	X	X	C	280
D	Y	Y	C	120
M	X	B	C	8
M	Y	B	C	2
				410

TRADE_TYPE	ORIGIN	CONSIGN	DESTIN	OBS_VALUE
R	X	B	C	80
R	Y	B	C	20
				100

After running QDR methodology for all HS6 products, the reference trade data set ITGS_REFERENCE is built which contains the final consolidated trade view broken down into quasi-transit, domestic and re-exports.

Results

Error! Reference source not found. shows the first five records of 11.8 million for 2010. It contains trade information for 176 countries + rest of the world.

PROD_STAGE	TIME_PERIOD	TRADE_TYPE	HS6	ORIGIN	CONSIGN	DESTIN	OBS_VALUE	UNIT_MEASURE	UNIT_MULT	DECIMALS	OBS_STATUS	CONF_STATUS
R	2010	D	010110	ES	ES	AD	0.7	EUR	3	1	E	N
R	2010	D	010110	AR	AR	AE	30.2	EUR	3	1	E	N
R	2010	D	010110	AT	AT	AE	5.1	EUR	3	1	E	N
R	2010	D	010110	AU	AU	AE	1657.9	EUR	3	1	E	N
R	2010	D	010110	CA	CA	AE	626.1	EUR	3	1	E	N
...	...	...	...	...	...	...	...	...	...	...	...	...

Table 4: Reference trade data for FIGARO at HS6 level

The QDR methodology is able to provide several indicators but probably the most important one is the domestic exports, i.e. exports that were originated in the economy of the exporting country, between a country of origin and a country of destination. This means that QDR is able to provide a breakdown by partner of exports vector in the use table of domestic inputs (T1611)[3].

As an example, the world trade of "motor vehicles, trailers and semi-trailers" (CPA_C29) in 2010 was estimated to be:

B€	EU	US	FIGX
EU	240.3	26.7	108.7
US	6.1	0	66.6
FIGX	43.7	124.1	175.9

Table 5: Global trade of motor vehicles, trailers and semi-trailers

The two biggest exporters of motor vehicles, trailers and semi-trailers in EU are Germany and France. Table 6 presents the domestic export of motor vehicles, trailers and semi-trailers for Germany and France, by partner (FIGX is the aggregate of all countries expect EU and US):

[3] Accounting for the fact that T1611 is valued at basic prices while trade statistics is valued at purchaser's prices.

B€	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HR	HU
DE	3.0	5.1	0.1	0.1	2.4	-	1.2	0.1	6.1	0.7	10.5	14.7	0.6	0.2	1.7
FR	0.6	3.7	0.0	0.0	0.5	6.0	0.3	0.0	5.5	0.1	-	3.5	0.1	0.1	0.2

B€	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	US	FIGX
DE	0.4	8.8	0.1	0.6	0.1	0.0	3.2	3.4	2.1	0.5	3.7	0.2	1.4	17.5	55.1
FR	0.1	3.5	0.0	0.1	0.0	0.0	0.8	0.7	0.6	0.4	0.6	0.4	0.5	0.6	9.0

Table 6: Domestic exports of motor vehicles, trailers and semi-trailers for Germany and France

In 2010, exports of domestic inputs (from use table T1611) for Germany and France, at basic prices, are 142.3B€ and 35.4B€. If we use the ratio for total inputs between purchaser's prices and basic prices and apply it to the use table for domestic inputs as an estimate of domestic exports at purchaser's prices, we get 145.0B€ for Germany, 1% more than estimates in ITGS_REFERENCE and 37.6B€ for France, 0.7% less than estimates in ITGS_REFERENCE.

As a concluding remark, QDR provides a reasonable and efficient way to break down domestic exports by partner, which is crucial for building an ICIO. In addition, there are other sort of indicators that can be derived from ITGS_REFERENCE that are useful for other type of analysis, e.g. re-export margins by country, physical movement of trade, estimates of quasi-transit, etc.

Acknowledgements

We are grateful to Eurostat colleagues in Unit G5: Goods – production and international trade, for their support and insights on the subject and is grateful with the cooperation and frequent dialogue with the OECD. The QDR methodology is also a product of the fruitful discussions during the FIGARO project.

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