**An endorsement-based Index for balanced Trade Flows in FAOSTAT**

# Abstract

This paper proposes an index for balancing a trade flow matrix based on the endorsement measure of bilateral trading partners. It represents an expansion of the widely accepted reliability index used in the GTAP model and other databases. The additional procedure is based on a clear distinction in the interpretation of overlap/agreement between the trading partners. In contrast to the GTAP reliability index, no attempt is made to draw direct inferences regarding the reliability of reporting. This was found to be difficult or outright impossible. Instead, the proposed measure is based on indirect inference that comes from the endorsement obtained from trading partners. The new methodology also relaxes several assumptions made in the GTAP trade methodology, allowing the index to distinguish between different partners and offering a more intuitive interpretation of reliability of trade reporting. This should provide an improvement on the GTAP solution in both its statistical soundness and the scope for a reliable interpretation.

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# Introduction

The FAOSTAT trade domain is one of the most important and most utilized datasets published by the Statistics Division of FAO. This high interest has also sparked concerns and additional requests for data presented in different forms or compilations. A trade dataset with completely balanced trade, i.e. where global imports are equal to global exports for every commodity is at the heart of many additional requests.

In an idealized trade matrix, a country’s imports are also another country’s exports. Each bilateral trade flow is defined by information about the product concerned, its monetary value and, ideally also the physical quantity of goods traded.

In theory, and if all trade flows were reported accurately, also in practice, the sum of exports should be close, albeit not exactly equal to, the sum of imports across all trading partners. In reality, however, there are often large discrepancies in the information reported by trading partners, leading to global trade imbalances. The discrepancies in bilateral flows are sometimes also referred to as *asymmetry of trade*. The asymmetry of trade flows is a well-recognised and well-documented phenomenon, including in UNSD’s Compiler Manual of the International Merchandise Trade Statistics (IMTS). The imbalance between figures reported by a reporting country and its corresponding bilateral trading partner may stem from several factors. They include divergences in reporting times, differences in the valuations of goods or losses occurred during transportation, to mention just a few.

These factors notwithstanding, there is a widespread demand for balanced trade data from the users of FAO trade statistics. For example, the construction of Input-Output Tables (IOT) or the trade flows needed for global equilibrium models require trade data to be balanced. Importantly, the FBS system requires balanced trade, the same holds for most equilibrium models. In fact, many of these models use balanced trade as a closure rule. Bringing imbalanced trade into equilibrium may require resolving conflicting trade information, and, as a consequence, overwriting a country’s officially reported trade data.

The approach presented here creates a fully balanced trade matrix, by harnessing maximum information inherent in trade flows, while minimizing the need to overwrite official data. The calculation of the index and the examples provided in this paper are based on trade flows measured in quantities. The same approach, however, can also be applied to value flows, at least after accounting for the inherent discrepancies between CIF and FOB values and addressing some additional complications that may stem from exchange rates swings.

The rest of the paper is organized as follows. It begins with a brief overview of various causes of imbalances, as well as the types of imbalance the new balancing method may help to address. A separate section is devoted to the description of the trade processing conducted by ESS and various trade dataset disseminated by FAO. Then, a brief background description is provided on existing methodological approaches, which eventually leads to the details of, and the motivation for, the new endorsement index. Finally, the paper offers some discussion and a preliminary set of conclusions.

**Classification and** then**ature of** i**mbalances**

This brief section is devoted to the explanation of the various sources of imbalances. It includes a list based on the analysis of trade asymmetries by EUROSTAT and provides an overview of issues that can be addressed by the proposed balancing algorithm; it also distinguishes between warranted imbalances, i.e. those due to valid reasons (CIF/FOB) and unwarranted ones, i.e. those that have occurred due to methodological issues.

One important issue to note is that trade flows have already undergone aggregation when they are being reported to the UN, or at least when they are being compiled by UN Comtrade. Initially, there could be thousands of imports and exports of a particular commodity between two countries. However, only one aggregated trade flow will be reported. As a result, it is almost entirely impossible to trace the exact source of an imbalance. That said, it is useful to distinguish two main sources of imbalances.

1. “Warranted” imbalances, which are justified even under a harmonised data collection system and a sound compilation methodology.
2. “Unwarranted” imbalances, which are due to methodological problems or application errors of the methodology or the data collection system.

Warranted imbalances: Even in a system with a perfectly harmonised methodologies and data collection systems[[1]](#footnote-1), certain imbalances may persist[[2]](#footnote-2). For monetary values, for instance, such imbalances are caused by differences due to transportation, freight and insurance, i.e. by differences reflected in FOB and CIF values; clearly such differences are not only unavoidable but warranted/necessary, as they reflect a proper application of methodologies and data reporting. But even for quantities, losses during handling, transport, or simply different reporting times can result in warranted imbalances. It should be noted here that an attempt is made to correct for time lags in reporting; these correction are based on monthly trade information available from GTIS[[3]](#footnote-3).

Unwarranted imbalances: Over and above these warranted imbalances, there are also discrepancies that reflect methodological shortcomings in collecting or compiling trade data[[4]](#footnote-4). These unwarranted imbalances can be addressed by a balancing algorithm. The next section will present a methodology on how such a mechanism could work in practice.

**Data Processing**

This section presents the data processing procedure for the balancing mechanism, the principal data sources used and the level of data granularity.

Raw trade flow data are obtained from UN Comtrade and GTIS. While GTIS data are available at a high level of disaggregation, for the balancing process details beyond the 6 digit level are pruned off. The time series starts in 1992, when the HS was officially adopted.

The raw trade flows first undergo a validation process, whereby trade unit values are examined and exposed to statistical tests for outliers and error detection. Then validated data are mirrored, so that missing trade flows are filled up with information from trading partners, where available. No official data are over-written at this point, all data are either reported by a country or their bilateral partners. Once mirroring and validation processes are completed, the balancing procedure is applied. During this step, conflicting official figures will be over-written by the value which obtained a higher endorsement index.

Ultimately, FAOSTAT will disseminate all three separate trade flow datasets described above: namely raw, validated & mirrored, as well as balanced. The user can then choose from the three variants and decide which level of processing best suits their requirements.

# Methodological background

In the past, various methods have been proposed to balance trade, from taking the simple average between the discrepant pairs, to maximum entropy weighted balancing. One key characteristic of the proposed methodology is based on the principle of minimizing the impact of balancing by modifying the lowest number of figures reported by the countries. Thus, methods which take the weighted average of the two trades and modifies both figures are not considered. Instead, a method which conveys the estimated ranking of reliability is chosen and trade is balanced according to the reported quantity which has the highest index associated with the value. Such an approach requires a scoring system to measure trade reliability.

The approach proposed here is based on the avenue taken in the GTAP[[5]](#footnote-5) methodology. But it provides several enhancements over GTAP reliability index. In the method of calculating the reliability index by GTAP, the degree of overlap of all trade flows of a reporting country with all of its trading partners is used as a proxy of the reliability of the country. The method attempts to infer the reliability of the reporting country through the agreement of reported figures and verifies this with its trading partners. The assumption is that countries which have a high level of consistency in reporting trade with their bilateral partners are reliable reporters and should therefore have a high score in the index. In addition to the degree of overlap, the calculation of the score is based on the number of agreed transactions. The reliability index should not be based on absolute quantities as large transactions should not have more weight than small ones; in fact the size of the transaction should not affect the reliability of a country’s reporting.

This practice also poses a number of problems and creates potential inaccuracies. Firstly, the method assumes that all the countries are trading with the same set of countries, which is generally not the case. Two equally reliable countries may result in a different reliability index only because one trades exclusively with highly reliable partners, while the other trades with unreliable ones. Secondly, it may not be appropriate to choose an exogenously assumed tolerance level in the calculation of the agreement. Instead the tolerance should be determined during the balancing process and be based on whether the discrepancy between two countries is deemed acceptable. Finally, the GTAP method assumes that agreement with a country’s partners has a positive effect on reliability. However, only agreement/overlap with high reliability countries should positively contribute towards the reliability index, while high agreement with a low reliability reporter should yield low reliability.

Available GTAP documentation does not elaborate on why a high level of agreement between a reporting country and its partner countries should be perceived as high reporting reliability. Nor is the calculation of such an index as a direct inference of reporting reliability justified.

## A New Index Based on Endorsement

The shortcomings of the reliability index, noted in the previous section, motivated the development of an index with more attractive properties and better interpretation. The new method attempts to address these new issues and constructs an alternative index that allows a balancing of the trade flow matrix via an endorsement by its trading partners.

There are several desirable properties, which we look for in an index for trade balancing.

1. The index should be positive and convey a ranking without ties.
2. Contribution of overlap towards the index should incorporate the differences in flows between the partners.
3. The index should increase as the number of trading partner increases, at least in a relative sense, given same level of agreement among all trading partners.
4. The index should not be based solely on a country’s trading partners, but also incorporate information based on the entire, i.e. global trading system .
5. The index is interpretable over time.

Property one is necessary in order to guarantee the process of balancing, trade flow will not be balanceable when the index for two countries has an identical value. The second point is straightforward, i.e. evidence from the partner countries should not be treated identically. For instance, a high agreement for a reporting country X with the United Kingdom (generally considered a reliable reporting country with advanced statistical capacity) should not have the same impact as an agreement with another country such as Afghanistan, which is here assumed to be a low reliability country. Third, as the number of trading partners increases (under the assumption that the overlap is equal), the index should always increase accordingly. For instance, if country A trades with 3 countries, while country B trades with only 2 then a higher value should c.p. be accorded to country A in the computation of the index. Property four is necessary in order to preserve a hierarchy. If an index is based solely on its immediate trading partners, then the hierarchy bears no meaning in the global sense, as no relationship is specified between all the participants in the trading network. Property five is not an essential criterion for trade balancing, as no balancing is required across different time frames. However, an index that is based on several years offers additional confidence and interpretation options.

## Defining endorsement

The basic idea behind the endorsement factor is to draw inference on how partner countries view the statistics reported by the reporting country, and then define a measure, which we call endorsement. This is different from the GTAP approach, where agreement is based on direct inference drawn from the reporting reliability of a country. That is, the endorsement based approach does not attempt to balance trade based on the reporting reliability of the country, instead balancing is based on the evidence available from all trading countries participating in a trading network. The difference is subtle, yet important, as making such direct inference is not possible and artificial relationships are assumed.

We define endorsement for each partner country j to a reporting country i as the percentage of agreement of trade between the two bilateral participants.

Where i denotes the indicator function, where reported bilateral trade flows are equal, and N is the total number of trade flows defined within a certain grouping between country i and j. The set j can be varied, from cover all trade to being specific to a given commodity and year.

The result represents the percentage of the trade reported by the reporting country supported by its trading partners. This is identical to the reliability index of GTAP, however, without allowing for an arbitrary tolerance and without removing the least reliable flows. Furthermore, endorsement is calculated per partner, not as one measure based on all partner countries.

The endorsement process produces a score for data quality, every partner country is a data quality examiner, and provides a numerical value, which reflects their judgement on the data quality of the reporting country.

## Computing the Endorsement Index

After the calculation of the endorsements of partner countries on the respective reporting country, the next step is to calculate a single index value for each country representing the total endorsement score. The solution is surprisingly straightforward. Provided that we have all individual endorsement scores, we can compute an overall index, which is equivalent to the sum of the endorsement weighted by the index of the corresponding partner.

Where i stands for the reporting country and j represents each corresponding partner, j represents all the countries trading with the country i. To perform this summation, we still require the endorsement indexes of all partners j, which is not readily available. What is more, this process does not yet guarantee that the same results are obtained when calculating the endorsement index of country j. Thus, we need to expand the above equation to ensure that this reciprocity condition is also met. This means that[[6]](#footnote-6):

That is, the solution will also satisfy the global balance equation. Again, the solution is surprisingly straightforward.

If we specify the pair of endorsements as a square matrix of dimensions KxK, where K is the number of countries involved in the trade at a global level and the matrix specifies the endorsement from country i to country j with empty diagonal entries, then the above solution can be obtained as the eigenvector of the endorsement matrix. According to the Perron–Frobenius theorem, the solution is unique and positive with its eigenvector, the endorsement index.

The method is also known as the eigenvector centrality, where the trade flow matrix is represented as a graph, and the endorsement matrix is the weighted adjacency matrix of the graph. The endorsement index of each country will be based on the endorsement of its partner countries, but at the same time the contribution will depend on the endorsement index of these partners. The solution is optimal globally, in the sense that all information between the bilateral partners are ultimately utilised globally.

## Properties of the Index

The summation of equation (1) guarantees that property three is satisfied. The endorsement index of country i is higher than country j, when i has more trading partners, even under the condition that the endorsement of country i and j from their corresponding partners is identical, and their trading partners have an identical index.

The property of accounting for difference in the trading partner is clearly inherited in the equation, where the endorsement index of the partner countries is also encompassed in the calculation of the endorsement index of the reporting country. This allows us to distinguish between various degrees of support from countries of high reliability to countries of low reliability.

The Perron–Frobenius[[7]](#footnote-7) theorem ensures that all endorsement indexes are positive and the solution is unique. Although the property of the index to have only unique values is not guaranteed, the value of the index will be unique under almost all conditions, except for the very unlikely situation where all trading countries have exactly the same endorsement for all partners.

Property four is nested in the global balance equation. The endorsement index of country i is dependent on the endorsement indexes of the set of countries, which trades with country j. In turn, the endorsement index of any of these countries also depends on K, which may not be a trading partner of country i. Thus, a relationship is established amongst all participants in the trade, and the rank is meaningful in a global context. To meet this condition in a graphical representation, this would amount to a network with strongly connected nodes. That is, every country is connected through its trading partner and reaches any other country trading in this network. This is not difficult to imagine and indeed achieve in a globalised trading network. Condition five is not directly met with the current framework; however, one can simply recode the numeric value of the endorsement index to a rank, and check how the rank changes over time.

## Trade Balancing Based on the Endorsement Index

In the FAOSTAT SWS implementation, the index is computed for each country and year, but aggregated at the commodity group level. The trade balancing can then proceed for each transaction, and in cases where there are discrepancies in the reported and partner values, the estimate associated with a higher endorsement index is chosen to replace the other.

**Conclusions**

The balancing mechanism presented in this paper is based on the reliability index proposed by GTAP; however, it differs from it in several key aspects. Firstly, the index is almost certainly unique, which is not necessarily the case in the GTAP method, particularly when based on countries with a small number of transactions. Secondly, the endorsement index departs from the GTAP approach of treating the agreement with a country’s partners in an equal manner. Agreements of a reporting country with partners that have high endorsement indexes provide stronger evidence than that of a high agreement with an unreliable partner. This property also accounts for the fact that the set of partner countries with which a given reporter trades is not the same. Furthermore, the new index constructs a meaningful hierarchy in the global network, rather than only with its immediate neighbours. This is crucial, as this connection amongst all participant countries is necessary, in order to have a meaningful index and for the purpose of balancing.

Finally, the endorsement based index allows for more intuitive interpretation. Indeed, it is difficult to follow the GTAP approach where agreement with partners is interpreted as reliability. The endorsement index, by contrast, represents data quality inherent in trade reporting from all participants.

# References

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1. Notwithstanding international standards set by the United Nations Statistical Division (UNSD) for the collection and compilation of trade statistics, considerable deviations persist at country level. [↑](#footnote-ref-1)
2. Discrepancies often arise from the adoption of different trade systems. Under the 'general' trade system, the statistical territory coincides with the economic territory and all goods entering the country are recorded and reported; while under the 'special' trade system, trade with free zones are not distinguished. Countries can collect data at various levels of detail, from 4 digits to 12 digits in the HS classification, and the balancing algorithm is justified in the context that it creates consistency in reporting standards. For example, if one exporting country was reporting under the 4 digit HS classification, while its corresponding imports were recorded at the 12 digit classification, the balancing mechanism would mean that trade would come under a single classification (whether 4 digits or 12 digits) depending on the reliability of reporting. [↑](#footnote-ref-2)
3. In parallel to the use of UN Comtrade data, efforts are underway to systematically use GTIS data as the basis for trade information. In fact a database has already been constructed that includes data from 85 GTIS countries at tariff line level plus all other countries from UN Comtrade at HS 6 level. This provides greater product-specificity as well as the possibility to undertake corrections for unwarranted differences arising from time lags in reporting. [↑](#footnote-ref-3)
4. If, for example, the majority of countries were to report trade under the general trade system and also the latest HS nomenclature, then a balancing algorithm would help overcome unwarranted discrepancies only and flows reported under the special trade system would be adjusted in line with the general trade system of their corresponding partners. [↑](#footnote-ref-4)
5. https://www.gtap.agecon.purdue.edu/resources/download/5116.pdf [↑](#footnote-ref-5)
6. Another way of interpreting the equation is that the amount of endorsement a country can give to its partners depends on how much endorsement it has received from all of the partners. [↑](#footnote-ref-6)
7. http://en.wikipedia.org/wiki/Perron%E2%80%93Frobenius\_theorem [↑](#footnote-ref-7)