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# Mirror Analysis and Revenue Fraud

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**Abstract**

This paper summarizes and proposes a methodology to support risk analysis and enforcement policies against Customs fraud, based on the use of mirrored data. The mirror analysis involves comparing mirror imports (or exports) of a country with exports (or imports) reported to this country by its partner countries to detect gaps in terms of quantities, weight or value that may unveil fraudulent flows or practices. This paper summarizes the research conducted in two WCO Member countries, and describes how this method can be applied.

**Key words**

Revenue, fraud, mirror data

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**List of acronyms**

HS: Harmonized Commodity Description and Coding System

OECD: Organisation for Economic Co-operation and Development

UNCTAD: United Nations Conference on Trade and Development

UNSD: United Nations Statistics Division

WCO: World Customs Organization

WITS: World Integrated Trade Solution

WTO: World Trade Organization

Mirror analysis (or mirror data) refers to the comparison between the import (or export) data of a country X and the data for imports to (or exports from) country X by one or more countries.

This paper was written based on research conducted by the WCO Research Unit and the School of Economics of Clermont-Ferrand University (France) using data and other information provided by the Customs administrations of Cameroon and Ecuador.[1] The paper provides initial feedback on experiences with the use of this method of combating revenue fraud.

From the point of view of Customs, mirror analysis is relevant to the following issues. Customs services know:

> (i) how to select cargoes on the basis of risk criteria or fraud profiles (Customs administrations have Customs computer systems with a selectivity module[2]),
> (ii) how to work out risk criteria or fraud profiles from analyses (an increasing number of administrations have teams specializing in risk analysis, targeting and investigation planning more generally).

The question that arises is to know how to carry out risk analyses in practice, or more precisely to decide to carry out an analysis in one area rather than another. The decision is based on a combination of (i) criteria that are subjective or external to the administration (political requirements, intuition and experience of Customs officials, (ii) intelligence and (iii) more objective approaches. In the case of the "objective" methods, the WCO risk analysis recommendations are a general intellectual framework which, for the deciding party in particular, is based mainly on analysis of the frauds identified (nationally and internationally) and an exchange of information with other enforcement administrations. Other methods are available, based on statistical methods for automating the process and assigning a "risk coefficient" to each Customs declaration (Geourjon *et al.*, 2013).

All those methods are effective. However, three questions remain:

1. What happens in an environment where corruption is a challenge? How can it be ensured that (i) action is taken against all the frauds detected and they are reported to the administration for inclusion in the risk analysis and (ii) the instructions for scrutiny resulting from the risk analysis are followed in the field?

2. How can new frauds be identified "objectively"? On what grounds can a risk analysis be undertaken in one area rather than another? Intuition, experience, intelligence and chance are effective methods, but can they be supplemented by an objective method?

[1] The WCO thanks the Cameroon Customs and the Ecuador Customs for having accepted to take part of this work and provided committed and skillful staff to follow the experiments.

[2] Whether or not those selectivity modules are operational, Customs is aware of their function and use. Their operational nature depends on the capacity of Customs to define its risk policy, for example.

3. How can risks be classified, given that some risks are "classifiable" or "quantifiable"? For example, the risk involved in the importation of drugs is not quantifiable. All drug seizures are socially and politically significant, and it is difficult to predict the impact if drugs are not seized. With commercial fraud, on the other hand, a quantitative relationship can be established between frauds: a fraud is measured quantitatively by its impact on revenue, which means that some frauds have more impact on revenue collection than others and the comparison among frauds is quantifiable and evaluable. How can optimum use be made of the resources available in order to focus the analysis?

Mirror analysis offers answers to those questions. It does not replace the experience of fraud control officers or other statistical methods; it is an adjunct to them.

This document is arranged as follows. The first section describes several theoretical aspects of the use of mirror data by economists, mainly to explain the background to mirror analyses and the methodological debate on the subject. The second section is a general discussion of what mirror analysis can and, above all, cannot do. Experience has shown that the response to mirror analysis is highly enthusiastic, but it may also be somewhat misunderstood. The third section describes the data preparation phase, how to find the data and how to organize them to make them easy to use. Many errors can be made in this crucial phase, distorting the whole analysis, and they cannot always be detected easily and quickly. The fourth section describes the possible stages of the analysis but this section does not propose any fixed methodology as, in combating fraud, it is necessary to be highly flexible in the conduct of any analysis. The fifth section explains the potential practical applications of mirror analysis.

A bibliography is available at the conclusion of this paper for readers seeking more information on the use of mirror data for risk analysis.

## 1. Theoretical aspects of mirror analysis

Mirror analyses have been used by economists for three main problems or purposes.

The first is the accuracy of international trade data. Economists have used mirror analyses to determine the opportunity criteria for the use of the data and the reasons for inaccuracies (Allen, 1960, 2012; Makhoul and Otterstrom, 1998; Barbieri *et al.*, 2009; Guo, 2009; Hamanaka and Tafgar, 2010; Hamanaka, 2011). Mirror analysis has thus been used to challenge the validity of the data for certain countries where these deviate too far from the statistical data of other countries which are considered reliable (Yeats, 1990). Gaulier and Zignago (2010) have suggested a method and created a database for harmonization of international trade data by reconciling the country data.

The second use of mirror data is the replacement of missing data. When the data for a country are not available or are considered wrong or unreliable, they are calculated from the import and export data of the countries that are its economic partners (Yeats, 1995; Choo, 2008; Barbieri *et al.*, 2009).

The third use of mirror analyses may be the most relevant for the reflection on the use of mirror data by Customs administrations: the approximation of fraud. The difference

measured between the data for a country X and those for its economic partners is considered – sometimes with a few adjustments – as an approximation of fraud. The wide availability of international trade data has been a major advance in the investigation of commercial fraud. Bhagwati (1967) has pointed out that one method used by economists in 1967 was to assess fraud through talks with people working in the field, but that had considerable and obvious limitations. Mirror analysis for the approximation of fraud has been used in many research contexts: for general "informal trade" assessments (Carrère and Grigoriou, 2014), to determine how monetary, fiscal or Customs policies encourage fraud (Bhagwati, 1964; McDonald, 1985; Fisman and Wei, 2004; De Boyrie *et al.*, 2005a, Mishra *et al.*, 2008; Kubo, 2012), to model the various types of fraud and their statistical detection (Bhagwati, 1981), to evaluate capital flight through international trade (Boyce and Ndikumana, 2001; De Boyrie *et al.*, 2005b).

Finally, some work combines mirror analysis with other statistical methods: mirror analysis and reports on obstacles to trade (for example *Doing Business*) to evaluate commercial costs per type of goods (Hamanak and Domingo, 2012); mirror analysis and consumption data for heavily taxed goods such as cigarettes (Nguyen *et al.*, 2014); comparison between national data and international averages to identify abnormal figures suggesting laundering (Zdanowicz, 2009).

Mirror analyses and the use of mirror data have been criticized for different reasons: their approximations, the lack of data[3], the fact that researchers sometimes tend to interpret the differences measured too quickly and too restrictively, when these could partly be explained by a number of factors (Nitsch, 2012), and, last reason raised by criticism, the fact that it cannot necessarily be assumed that the data provided by partner countries are correct (Hamanaka, 2012).

In fact, the difference measured by mirror analysis might be due to reasons other than fraud:

– incorrect tariff classification, but this can be detected if it is systematic (Bhagwati, 1964);

– a time lag, with exports from country Y for one year arriving in country X the following year, but that time lag will most probably have the inverse effect on the current year (Bhagwati, 1964);

– a mistake in provenance, an import to country X is ascribed to exporting country Y when it was actually exported from Z, but that error is only significant for the analysis of bilateral flows; in the case of a mirror analysis for fraud in imports to country X, provenance is merely a secondary aspect, to be used as a basis for more detailed analyses;

– an error in declarations of exports to country X;

[3] When those methods were first used in the 1960s and 1970s, foreign trade figures were not publicly available, or at least only for the OECD countries (Bahgwati, 1967). With the UN-COMTRADE database, that is no longer the case.

– currency conversion errors and the effects of devaluation (De Wulf, 1981);

– entry of transport and insurance costs in the accounts if the comparison is between CIF and FOB figures[4];

– different recording by the reporting countries of data for transit or transhipment or for trade via third countries more generally (Ferrantino and Wang, 2008; Barbieri *et al.*, 2009).

This economic literature provides many examples of the use of mirror data, but its main value for Customs lies in the methodological and theoretical discussion of the possible use of international trade data. Apart from giving possible explanations for differences between mirror data, the criticism by economists shows that it is not possible to determine the exact amount of the fraud by mirror analysis or any other method. On the other hand, the whole advantage of mirror analysis, since it is quantitative, empirical and not speculative as a risk analysis based solely on total individual experience might be, is that it enables the presumed scale of the fraud to be classified. In focusing inspections, not being able to assess the amount of fraud precisely as an absolute value is less important than being able to assess the relative amount of fraud per type of trade flow and between potential frauds.

## 2. What mirror analysis can (and cannot) do

Generally speaking, any fraud relating to type, quantity, value and origin can potentially be detected by mirror analysis, provided that the data are available and correct.

Mirror analysis cannot, on the other hand:

(i) compare data between declarations or undertakings; the public data available are aggregated for each product and country (HS 6-digit level for the Harmonized System);

(ii) be carried out for the current year, since data for year N are usually available in year N+1. However, it is recommended that changes in the COMTRADE database are monitored. One of the developments announced is the supply of monthly figures by certain countries.

## 3. Data preparation

Mirror analysis requires data preparation: the collection and organization of external and local data in the same system to allow them to be compared and processed. This is a delicate phase, on which the accuracy of the analyses will depend. The data corpus is large (for local data several gigabytes), and the analysis processing is automated, which exacerbates the effects of wrong collection or errors in the initial organization of the data.

[4] Nonetheless, this error should not exceed a small percentage of the value.

*3.1. Downloading data for partner countries*

Foreign trade data for partner countries are available on the UNSD (United Nations Statistics Division) COMTRADE database. The UNSD collects the data from member countries annually. Access to the data is open and free of charge.

N.B.: with free access, data downloads are limited to 50,000 lines. It is possible to take out a special subscription, or the download can be broken down (for instance by years or groups of tariff headings).

The COMTRADE database is available on two websites:

– the United Nations website, http://comtrade.un.org

The website gives information on the availability of data, collection methodology, etc.

– the WITS website, http://wits.worldbank.org

The WITS website has been developed by the World Bank, UNCTAD, UNSD and the WTO. The raw data are the same as on the UN's COMTRADE website. WITS provides visualization tools, databases of national tariffs and international trade agreements, and macro-economic simulation tools. These may be downloaded from the website with an individual account. This account is free of charge and obtainable simply by sending an e-mail request to the WITS administrator.

The fields for interrogation of the database are identical for both websites.

| **Parameters** | **Choice of HS nomenclature** | **Remarks** |
|---|---|---|
| Reporter | Country reporting its data to the UN's COMTRADE database (not to be confused with "Partner") | With mirror analysis of imports, "Reporters" are the countries exporting to the country concerned. |
| Partner | Country to which mirror analysis relates | |
| Periods (years) | Years examined | Available data must be checked first. Often complete data for the year before the current year are not available until the first half of the current year.<br><br>It might be worth checking the information on the availability of data for years and partner countries. It is possible that not all countries will have reported their data at the time of the study, but some countries might not be regular or major partners of the country |

| | | |
|---|---|---|
| | | concerned. In that case, the incompleteness of the data is not a serious obstacle.<br><br>http://comtrade.un.org/db/mr/daReportersResults.aspx |
| Products/ Product groups | Products according to tariff nomenclature | Different groupings may be chosen for each tariff chapter, heading or subheading. Maximum precision for the Harmonized System is the 6-digit subheading. |
| Imports/Gross Imports/ Exports/Gross Exports … | Choice of trade flow for "Reporter" country | For a mirror analysis of imports, this will be "exports" or "gross exports". |

Example of use in WITS:

– select *Advanced Query-Trade Data (UNCOMTRADE)*;

– choose *new query* for a new request and enter a request name (that request will be protected and may be re-used, with different parameters if necessary);

– choose *reporters*, countries that are partners of the country concerned, and preferably select all countries;

– choose products: choose the nomenclature used then, for example for the HS, choose in "clusters" the level of precision (chapter, heading, subheading, *ALL1*, *ALL2*, *ALL3*);

– choose the country in question as *partner* country, the year or years examined and the flow (of exports for a mirror analysis of imports, of imports for a mirror analysis of exports);

– request download of results from the request;

– choose the export format (usually CSV) and the fields to be exported (which will be in columns in the result file): fields for *reporters*, products and years and fields for values and quantities (quantities are available both in units and in weight, sometimes the two fields are identical when the unit is a unit of weight). The values are shown in thousands of US dollars (USD) and the weights in kilograms (kg).

– download. N.B. check the last field "total rows" in the download display. If it shows the number of lines downloaded as 50,000, the limit has most probably been reached and the number of lines in the result exceeds that limit. It is then necessary to re-start the request and break it down (e.g. by year or group of products).

*3.2. Downloading local data*

Local data are the data available from Customs declarations that are lodged into the IT Customs clearance system. When these local data are downloaded, obviously the same fields are needed for the analysis: exporting country, date of importation, HS code for

goods, value (if possible with details of invoice value of goods and value of transport and insurance costs), net mass quantity, additional units.

Special attention must be paid to the various Customs regimes, in order not to enter the same goods more than once. The principle is to obtain a table showing everything that has entered the territory in a given period (and not, for example, only what has been released for free circulation or home consumption).

In addition to the specifically mirror data from COMTRADE, other local data may be downloaded for further analysis: for example the office of entry, information as to whether the declaration has been adjusted, exporter and importer references, declarants, the Customs regime, declaration processing dates, etc. However, some data should not be downloaded, in particular the text fields describing the goods. It is preferable to download a large number of fields to facilitate analysis, whilst bearing in mind that the size of the table obtained will add to the processing time. If the file is too large, the computer processing will take longer. It is therefore necessary to find a balance between the fields that might be relevant to the analyses, the computer processing capacity available and the size of the final data table.

*3.3. Creating a database*

Thus two files have been created after those two downloads:

– one from COMTRADE with the aggregated data (partner country, HS 6-digit product, value in USD, quantities in units, net weight);

– one from Customs declarations with data for each clearance, which will need to be aggregated in order to be comparable with the COMTRADE data, but also preserved in their original form for further analysis.

It must be possible to process the two files in the same system. It is initially recommended that two tables be set up in the same system, one for importation of the partner countries data file and one for importation of the local data file. It is recommended that all data (external and local) be kept in the same system, even if expurgated tables have to be created for fast processing.

There are two possible solutions, to use either statistical software [5] or database management software[6].

It is strongly advised that spreadsheets are not used, since these require extensive pre-processing for each analysis.

No particular recommendations can be made for the choice between statistical and database software. Powerful software of both types is available free of charge. The choice depends on the skills and knowledge of the processing staff. The advantage of statistical software is that it facilitates mathematical treatment and can even be used as a basis for

[5] For example, R is free downloadable software on http://www.r-project.org/.
[6] For example MySQL Community Edition is free and downloadable on http://www.mysql.com/.

subsequent econometric analysis. Some statistical software has the disadvantage that the speed of data handling is lower than with database management software.

Importing the two original files (partner countries data file and local data file) is an extremely delicate operation. To avoid wasting time, prior testing with small files is strongly recommended, for instance by importing only one month's local data.

Three points in particular must be checked, since they result in importation errors without impeding the importation process, making them difficult to detect unless they are examined specifically:

– adherence to local data date formats;

– missing data and how they are imported to be taken into account in the mathematical operations (missing data are not zero quantities);

– the decimal symbol varies from one geographical region to another, and in some systems a symbol might be added for thousands.

After the original files have been imported, it is recommended that sets of aggregated data be created to expedite processing. For instance, to compare HS 6-digit exports directly with HS 6-digit imports, it is necessary to work on the local data table: aggregate the data based on the basis of the HS 6-digit subheading (and the year if several years are involved) to obtain a table comparable to the COMTRADE export table (HS 6-digit, year, exporting country, FOB value, quantity, weight). The field values are to be expressed in the same units: USD, kg and tonnes.

## 4. Possible stages in a mirror analysis

The purpose of a mirror analysis is to provide a quantitative classification of products or flows at risk. Hence these are estimates of fraud and there is therefore no specific methodology which, if followed step by step, would give a typical and reliable result. Mirror analysis can only be an empirical process, sometimes intuitive and involving Customs know-how and knowledge of the field to guide the analyst in the data corpus. It would be dangerous and unproductive if one were confined to a system of analysis that was applicable to all situations. However it is possible to identify a few approaches that have produced results in the field.

### *4.1. General analysis of data*

– number and proportion of HS 6-digit products in the two data subsets (partner countries data and local data),

– number and proportion of couples (HS 6-digit products, partner country) in the two data subsets (partner country data and local data),

– classification by chapter or type of product or by tariff heading or subheading according to value, number of transactions or relative proportion of the value of the product to the total imported value (using local and COMTRADE data or local data alone),

– an identical classification for partner countries to identify major partners.

This initial analysis is necessary for several reasons:

(i) to detect errors (for example a large number of products appearing in only one corpus; proportion for a partner country known to be a major partner not shown or too small) due to the collection process (no data in the COMTRADE database) or organization of the data (errors in the importation of local data);

(ii) to detect anomalies that might provide an early indication of where enquiries should be focused (for example when a trade flow appears in the COMTRADE data and not in the local data);

(iii) in particular, for familiarization with the main characteristics of the trade flows (main products, main partner countries) in order to be aware of anomalies immediately on progressing to a more specific level of flow analysis.

*4.2. Calculating differences between local and COMTRADE data*

The mirror analysis as such involves evaluating the differences between local and COMTRADE data.

What is the basis for calculation of those differences?

– values, net mass, quantities¸ value density by mass and quantity (value by weight, value by unit).

How are the differences expressed?

– as absolute values (USD, weight, number, USD/kg, USD/unit),

– as relative values, e.g. percentage of difference in FOB value compared with imported FOB value.

At what aggregation levels are the differences calculated?

– partner country x year/period,

– HS 6-digit (or HS 2-digit or HS 4-digit) x year/period,

– HS 6-digit (or HS 2-digit or HS 4-digit) x partner country x year/period.

It is recommended that the various analysis levels are planned in advance.

Finally, it is recommended that products for which the differences are negative (COMTRADE data > local data) are separated beforehand from products for which the differences are positive (COMTRADE data < local data). In the event of tariff slippage at HS 6-digit level, for example, calculation of the difference at HS 4-digit or HS 2-digit level might show the difference as zero. It is therefore important to start working at the most disaggregated level possible (HS 6-digit even couple (HS 6-digit, partner country))

to detect all differences and identify separately all negative differences and positive differences before progressing to more aggregated levels.

*4.3. Detailed case studies*

At the previous two stages, it has been possible to detect the most significant differences in value, quantity, mass, value density, overall or by partner country. That provides an initial classification of the scale of potential fraud. It is then necessary to select specific cases (products or couples (products, countries)) from the main differences noted in the light of knowledge of the field and the tariff and regulatory data (minimum values, tax pressure, sector subject to exemptions or restrictions on quantity or special licences). The individual case study should lead to the development of a hypothesis of fraud or rejection of the hypothesis if there are other possible explanations for the difference.

It is complicated to establish a case typology, and even if one were to exist it would not help the analysts, who have to examine each specific case in detail in any event. The following is not an exhaustive list of the situations encountered[7]:

(i) **A significant negative difference in quantity and value for an HS 6-digit product (more declared quantities exported to the country concerned than quantities declared for import by that country).** It is then worth looking for tariff slippage: products similar to the targeted product but taxed less than that product (for instance in the same heading or chapter), with an equivalent but positive difference (the quantity of the product declared for importation is greater than the total quantities declared for export by the partner countries). The typical case is that of vehicles of all types supposedly imported as spare parts. If no tariff slippage is noted, these might be contraband. An indication might be retention of the negative difference when the difference is calculated for the chapter. If the difference for the chapter is equivalent to the negative difference found, there has probably been no tariff slippage. If, on the other hand, the difference for the chapter is zero, the negative difference for the product has probably been offset by a positive difference for another product[8].

(ii) **A negative difference in value but no significant difference in quantities.** In such cases, it might be worth going back to the level of local declarations and calculating the import value density for each importer to detect any significant differences that might point to undervaluation by some importers. If all import value densities are close or identical, certain major importers might have formed a cartel for the undervaluations. The same calculation can be made for each Customs office used as a point of entry, in order to identify bad local practices aimed at attracting traffic. The same calculation can also be made for each partner country – some importers have special links to certain exporters operating in particular countries – to examine the possibility that the imported products of are very different quality.

[7] See Raballand *et al.* (2013) for a published case study.

[8] This merely illustrates a research method. Each case is distinct, but this method, which varies aggregation levels between HS 6-digits, HS 4-digits and HS 2-digits, has produced positive results.

(iii) **A positive difference in value (the value declared on importation into the country concerned is higher than the total values declared on exportation by the partner countries).** Such cases might be linked to the manipulation of transfer prices, as a cover for tax fraud laundering. That might be explored by comparing value densities per importer in order to identify a major importer importing at very high values.

(iv) **A positive difference in quantities.** There might be numerous explanations for this: transit, regulations in the importing country which do not allow any exemption for resident travellers or use of the product to cover up contraband offences.

(v) **A strong link between transport and insurance costs and the value of the goods.** Since the COMTRADE data are FOB, they can be used to evaluate the proportion of values declared for importation represented by transport and insurance costs, when the local data on such costs are not or are no longer available or are suspect.

It is not possible to discuss every case in detail; the interpretation depends on the local context (Customs regimes, specific laws on values, quotas and exemptions). The analysis must be flexible and it is therefore necessary for the source data to be preserved and the processing to be done on separate tables.

*4.4. Providing an assessment of potential revenue losses*

Finally, the potential revenue losses are estimated for each case. This is an important stage, since the biggest differences in values or quantities do not necessarily generate the biggest revenue losses.

It is recommended that intervals be applied for revenue losses, taking the limit values for the COMTRADE and the local data. For instance, with a negative difference of quantity X on a product P, a value and a tax pressure applicable to it must be reconstituted:

– minimum, average, median and maximum value densities can be applied to the missing quantity X,

– similarly, an average, median, minimal or maximum tax pressure on product P can be calculated from the local data.

In the event of tariff slippage, the revenue generated by the product to which the missing quantities have been carried over, which is revenue actually collected, is to be deducted from the estimated losses of revenue.

**5. Uses of mirror analysis**

The purpose of mirror analysis is not to produce a document but to combat fraud. It must therefore be part of the enforcement framework. That can take several forms:

(i) mirror analysis is used in discussions between Customs, the private sector and government, to provide a quantitative assessment of fraud in one or more sectors;

(ii) mirror analysis provides the main focus of an annual fraud control plan;

(iii) mirror analysis is used directly to define primary risk criteria that will be implemented in the IT Customs clearance system or to guide investigations and *ex post* inspection;

(iv) mirror analysis is brought in to restrict bad practice by investigators. Managers in the investigation branches may require their investigating officers to carry out a simple mirror analysis prior to the opening of investigations. The analysis should show the potential estimated revenue losses. That has two advantages for managers: before the investigation, the manager of the enforcement officer can assess whether the investigation that has been suggested is appropriate in the light of other possible potential fraud cases and after the investigation, the manager can evaluate the effectiveness of the investigation by comparing the adjustments made to the potential adjustments reported by the investigating officer[9].

(v) mirror analysis can lead to an experimental fraud control system, focusing on the major cases identified, whose effectiveness is measured over time. Such an experimental system can be useful in evaluating or orienting the work of frontline offices. After discussion of the cases described with frontline officers, supplemented by further cases they suggest, certain trade flows (products or products-countries) are selected for closer inspection for a limited period (a few months). In that period, the mirror analysis team continues to measure values, quantities and, in particular, value densities for the goods cleared through Customs, as well as any disputes. At the end of that period, a report can be drawn up on the relevance of the fraud hypotheses, the effectiveness of the frontline inspection services (at least in carrying out inspections of the target products) and any changes of importers' behaviors and practices (importers might, for example, have increased their values or reduced their frauds following disputes or their realization of the stricter controls).

In all cases, once the cases and hypotheses have been drawn up, it is important to compare them with the experience of frontline inspectors and investigators. It might be tempting to take their experience into account from the start of the mirror analysis and to focus the enquiries on the basis of their information. That is not recommended, for two reasons. Firstly, the mirror analysis and experience in the field can always be compared at any point in the analysis; the two approaches are not mutually exclusive. Secondly, mirror analysis is specifically an objective counterpart to human experience in fraud control. On the other hand, it is absolutely essential to compare the case studies and fraud hypotheses with the experience of officers in the field at the end of the analysis.

[9] Thus, investigators might either have made an incorrect analysis, knowingly or otherwise, or have erred in their inspection. In either case, mirror analysis provides a basis for evaluation of the work and practices of investigating officers prior and during the investigations.

## 6. Bibliography


Allen, Robert Loring. 2012. *Soviet Economic Warfare*. Literary Licensing, LLC.

Barbieri, Katherine, Omar M. G. KeHSk and Brian M. Pollins. 2009. "Trading Data Evaluating Our Assumptions and Coding Rules". *Conflict Management and Peace Science* 26 (5): pp. 471–91. doi:10.1177/0738894209343887.

Bhagwati, JagdiHS. 1964. "On the Underinvoicing of Imports 1". *Bulletin of the Oxford University Institute of Economics & Statistics* 27 (4): pp. 389–97. doi:10.1111/j.1468-0084.1964.mp27004007.x.

———. 1967. "Fiscal Policies, the Faking of Foreign Trade Declarations, and the Balance of Payments". *Bulletin of the Oxford University Institute of Economics & Statistics* 29 (1): pp. 61–77.

———. 1981. "Alternative Theories of Illegal Trade : Economic Consequences and Statistical Detection". *Weltwirtschaftliches Archiv* 117 (3): pp. 409–27. doi:10.1007/BF02706100.

Boyce, J.K., and L. Ndikumana. 2001. "Is Africa a Net Creditor? New Estimates of Capital Flight from Severely Indebted Sub-Saharan African Countries, 1970-96". *The Journal of Development Studies* 38 (2): pp. 27–56. doi:10.1080/00220380412331322261.

Carrère, Céline, and Christopher Grigoriou. 2014. *Can Mirror Data Help To Capture Informal International Trade?*. UNCTAD Blue Series Paper 65. United Nations Conference on Trade and Development. https://ideas.repec.org/p/unc/blupap/65.html.

Choo, Jaewoo. 2008. "Mirroring North Korea's Growing Economic Dependence on China: Political Ramifications". *Asian Survey* 48 (2): pp. 343–72. doi:10.1525/as.2008.48.2.343.

De Boyrie, Maria E., Simon J. Pak and John S. Zdanowicz. 2005. "The Impact of Switzerland's Money Laundering Law on Capital Flows through Abnormal Pricing in International Trade". *Applied Financial Economics* 15 (4): pp. 217–30. doi:10.1080/0960310042000313200.

De Boyrie, Maria E., Simon J. Pak and John S. Zdanowicz. 2005. "Estimating the Magnitude of Capital Flight due to Abnormal Pricing in International Trade: The Russia–USA Case". *Accounting Forum*, Tax avoidance and global development, 29 (3): pp. 249–70. doi:10.1016/j.accfor.2005.03.004.

De Wulf, Luc. 1981. "Statistical Analysis of Under- and Overinvoicing of Imports". *Journal of Development Economics* 8 (3): pp. 303–23. doi:10.1016/0304-3878(81)90018-3.

Ferrantino, Michael J., and Zhi Wang. 2008. "Accounting for Discrepancies in Bilateral Trade: The Case of China, Hong Kong, and the United States". *China Economic Review* 19 (3): pp. 502–20. doi:10.1016/j.chieco.2008.02.002.

Fisman, Raymond, and HSang-Jin Wei. 2004. "Tax Rates and Tax Evasion: Evidence from 'Missing Imports' in China". *Journal of Political Economy* 112 (2): p. 471.

Gaulier, Guillaume, and Soledad Zignago. 2010. *BACI: International Trade Database at the Product-Level (the 1994-2007 Version)*. SSRN Scholarly Paper ID 1994500. Rochester, NY: Social Science Research Network. http://papers.ssrn.com/abstract=1994500.

Geourjon, Anne-Marie, Bertrand Laporte, Ousmane Coundoul and Massène Gadiaga. 2012. "Inspecting Less to Inspect Better". In *Reform by Numbers: Measurement Applied to Customs and Tax Administrations in Developing Countries*, pp. 83–102. World Bank Development Series. Cantens, T., Ireland, R., Raballand, G.

Guo, Dong. 2009. *Mirror Statistics of International Trade in Manufacturing Goods: The Case of China*. Working Paper 19/2009. UNIDO.

Hamanaka, Shintaro. 2011. “Quality of the Trade Statistics of the Lao PDR Incompatibility with International Standards and Inaccuracies due to Smuggling”. *South East Asia Research* 19 (3): pp. 595–633. doi:10.5367/sear.2011.0057.

———. 2012. “Whose Trade Statistics Are Correct? Multiple Mirror Comparison Techniques: A Test Case of Cambodia”. *Journal of Economic Policy Reform* 15 (1): pp. 33–56. doi:10.1080/17487870.2012.657827.

Hamanaka, Shintaro, and Romana Domingo. 2012. “Measuring Long-Term Commodity-Level Trade Costs: The Case of Asia”. *Journal of International Commerce, Economics and Policy* 03 (02): 1250014. doi:10.1142/S1793993312500147.

Hamanaka, Shintaro, and Aiken Tafgar. 2010. *Usable Data for Economic Policymaking and Research? The Case of Lao PDR”s Trade Statistics*. 87. Asia-Pacific Research and Training Network on Trade Working Paper Series. http://www.econstor.eu/handle/10419/64284.

Kubo, Koji. 2012. “Trade Policies and Trade Misreporting in Myanmar”. *ASEAN Economic Bulletin* 29 (2): pp. 146–59.

Makhoul, Basim, and Samuel M. Otterstrom. 1998. “Exploring the Accuracy of International Trade Statistics”. *Applied Economics* 30 (12): pp. 1603–16. doi:10.1080/000368498324689.

McDonald, Donogh C. 1985. “Trade Data Discrepancies and the Incentive to Smuggle: An Empirical Analysis (Divergences dans les données sur les échanges commerciaux et attrait de la contrebande: Analyse empirique) (Discrepancias de los datos sobre el comercio e incentivo al contrabando: Análisis empírico)”. *Staff Papers (International Monetary Fund)* 32 (4): pp. 668–92. doi:10.2307/3866743.

Mishra, Prachi, Arvind Subramanian and Petia Topalova. 2008. “Tariffs, Enforcement, and Customs Evasion: Evidence from India”. *Journal of Public Economics* 92 (10–11): pp. 1907–25. doi:10.1016/j.jpubeco.2008.04.017.

Nguyen, Minh Thac, Ryan Denniston, Hien Thi Thu Nguyen, Tuan Anh Hoang, Hana Ross and Anthony D. So. 2014. “The Empirical Analysis of Cigarette Tax Avoidance and Illicit Trade in Vietnam, 1998-2010”. *PLoS ONE* 9 (1): e87272. doi:10.1371/journal.pone.0087272.

Raballand, Gaël, Thomas Cantens and Guillermo Arenas. 2013. “Mirror Trade Statistics: A Tool to Help Identify Customs Fraud”. In *Reform by Numbers: Measurement Applied to Customs and Tax Administrations in Developing Countries*, pp. 103–20. World Bank Development Series. Cantens, T., Ireland, R., Raballand, G.

Volker Nitsch. 2012. “Trade Mispricing and Illicit Flows”. In *Draining Development?: Controlling Flows of Illicit Funds from Developing Countries*. The World Bank, pp. 309–34. Peter Reuter.

Yeats, Alexander J. 1990. “On the Accuracy of Economic Observations: Do Sub-Saharan Trade Statistics Mean Anything?”. *The World Bank Economic Review* 4 (2): pp. 135–56. doi:10.1093/wber/4.2.135.

———. 1995. *Are Partner-Country Statistics Useful for Estimating Missing Trade Data?* SSRN Scholarly Paper ID 636143. Rochester, NY: Social Science Research Network. http://papers.ssrn.com/abstract=636143.

Zdanowicz, John. 2009. “Trade-Based Money Laundering and Terrorist Financing”. *Review of Law & Economics*, 5 (2): pp. 855–78.