Towards time-consistent bilateral FDI statistics: A new dataset covering 2001-2022

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Abstract:
During the 2008-2010 financial crisis, OECD and IMF changed the definition of foreign direct investment (FDI) to get better information on intra-company financing activity. The new definition gives financing activities by subsidiary affiliates of multinational companies the same status as equity-based managerial control of foreign firms. It resulted in a systematic drop of quality, informative content and consistency of FDI statistics, as is frequently signalled in the literature. We propose a new formal framework for achieving time-consistent FDI data. It emulates the FDI definition of before 2013 that was based primarily on FDI assets. We develop a formal framework for this method and provide a full proof-of-concept. We constructed a new long-term dataset, called UIFS4. The database is a balanced panel covering bilateral FDI between 232 jurisdictions over the period 2001-2022. The dataset is solely based on reported data and uses no estimation or imputation. The performance of UIFS4 is evaluated quantitatively in a comparison with the original source data.

Keywords: foreign direct investment (FDI); balance of payments; multinational companies; capital account;
JEL codes: F21; C18; C55; C82; F23

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Introduction

Foreign direct investment (FDI) statistics form an important information source for the direction and volume of inter-country investment traffic of hierarchically related companies. FDI is a concept that comes from the capital account of the balance-of-payments, which quantifies a country's economic long-term transactions with other countries. Statistics on FDI are widely available and over a considerable time period. They are broadly used in empirical research on international investment relations. Nonetheless, anyone who has been working with bilateral FDI statistics may have noticed at least some problematic issues with these data. FDI data are compiled by different organisations, often with a different approach. Two partner countries may report different values for their bilateral FDI traffic. Many bilateral values are suppressed for confidentiality reasons, or they are simply missing. Time series display sharp jumps after 2009 that are difficult to explain.[1] One finds negative bilateral investment, which may have brought some to wonder how real investments can be negative.[2] Furthermore, one finds countries with tiny domestic economies that report huge amounts of inward and outward FDI, probable related to the use of tax-avoiding constructions.[3] At the aggregate level, one would expect that total inward and total outward FDI would be more or less in balance because they are bilateral transactions that are registered by the receiving country and by the `sending' country. However, one finds large gaps between totals for inward and outward FDI at world level. These are not just a few percents due to statistical discrepancies, but double-digit gaps, indicating the existence of large non-attributable volumes of FDI. The aformentioned issues raise valid questions about the quality and consistency of international FDI statistics. There is increasing uneasiness of researchers about the quality, informative content and effectiveness of current foreign direct investment statistics. Several authors have argued that FDI data form a bad proxy for the size of business investment in other countries, and for the activities of multinational companies.[4]

The paper presents a new formal framework that allows to quantify FDI data quality and data consistency issues. The paper indicates several steps to address or at least reduce several of the aforementioned problems. We propose a feasible way to achieve more time-consistent FDI statistics. And last but not least, we show this by a full-blown proof-of-concept. We test this result by comparing it to the key sources of FDI statistics.

What news brings this paper to the literature? The first contribution of the paper is that we indicate the importance and consequences of the 2009 change in the definition of FDI itself. This element has almost completely escaped the attention of researchers in the area. In the heat of the 2008-2010 financial crisis, there was overall anxiety among monetary authorities about a possible financial break-down. One of the fears concerned the possibility that intra-company cross-border lending activities of multinationals

[1] Cf. Pogliani *et al.*, 2022; Claassen and Van der Dool, 2013; Working Group on International Investment Statistics, 2008.

[2] Cf. Elkjaer and Anacki, 2023; IMF (2024).

[3] Cf. Hansen *et a*l., 2024; 2023; Damgaard *et al*., 2024, 2019; Tørsløv *et al*., 2023; Florez-Orrego *et al.* 2023; Coppola et al., 2021; Garcia-Bernardo et al. 2021, 2017; Casella, 2019; Martinez-Galan and Fontoura, 2019; Shaxson, 2016; Borga and Caliandro, 2018; Zucman, 2014, 2015.

[4] Cf. Casella *et al.*, 2023; IMF, 2018; Blanchard and Alcalin, 2016; Wacker, 2013; Lipsey, 2010; Beugelsdijk et al, 2010.

could generate major financial skeletons-in-the cupboard with unpleasant surprises. There was a lack of information on this part of the financial markets. At the end of 2008, IMF and OECD decided that intra-company cross-border loan activities of subsidiaries within multinational companies would from then onwards also be considered as a direct investment. This implied that they effectively changed the definition of FDI. The paper shows that this created a major consistency break in FDI time series. The change has had big consequences in the form of inflated FDI figures, a frequent occurrence of negative FDI stock values, double counting, the loss of the mirror checks[5] on bilateral FDI traffic, and loss of FDI's unique 'selling point' as being the sole statistic that measured cross-border hierarchical relations of multinational companies.

The second contribution of this paper to the literature is that it provides a new formal framework for a controlled, selective use of the mirror statistics in combination with a multi-criterion selection procedure for evaluation of data quality. The framework yields quantitative indicators for analysing the quality of the FDI data. The mirroring algorithm that we use is also applicable outside FDI statistics; it can be used as well for other bilateral data, such as trade and finance data.

The third contribution is the UIFS4 database of bilateral FDI statistics. It is a 'proof of concept' with quite huge proportions, compared to existing FDI datasets. UIFS4 has a full panel structure with 557,000 data cells filled with numerical information on the bilateral FDI stocks between 232 jurisdictions over a period of 22 years. The database is built on the formal framework in combination with explicit rules for the selection of mirror data in the case that multiple sources are available. The rules includes a use of knowledge on the statistical capabilities of both partner countries, the type if role they play in tax-avoidance chains, offshore finance hubs, and a preference for data that not compiled under the post-2008 double-stand FDI definition. The UIFS4 database is strictly based on reported bilateral data (IMF, OECD, UNCTAD, Eurostat and ASEAN). It uses no estimations or imputations to fill individual data cells. The database applies a strict separation between zeros and missings. The dataset might become an asset for research on economic globalisation and international economic relations.[6]

Finally, the paper compares UIFS4 against its main orginal-source data (IMF, OECD, UNCTAD, Eurostat), showing that the new database performs strongly in terms of time consistency, aggregation consistency, and the number of numerical FDI observations.

The structure of the rest of the paper is as follows. Section 1 discusses the change in FDI definition that was introduced by the IMF in 2009 as an important discontinuity in statistics on bilateral direct investment stocks. Section 2 gives our basic assumptions for a reconstructed and consistent long-term FDI dataset across the statistical break. Section 3 models a full formal framework for the re-construction of a consistent long-term data set of bilateral stocks, and for the identification of FDI over-reporting by

[5] This refers to using the statistics of the partner country as a consistency check for the reported bilateral FDI traffic.

[6] The Unified Inward FDI Stocks (UIFS4) database covers 22 years, starting in 2001 and including 2022. The number of countries is 233, yielding almost 55,000 bilateral data cells per year. On average 21,000 annual data cell are filled with numerical information. The UIFS4 database complements the 'external wealth of nations' project (Lane and Milesi-Ferretti, 2011, 2018), but also the Stanford-NBER project on 'redrawing the map of global capital flows', which now predominantly focuses on portfolio capital (Coppola et al., 2021; Maggiori et al., 2020; Florez-Orrego et al., 2023). The UIFS4 database will be made publicly available upon publication of the paper. It includes a replication package for the construction of the database.

countries. Section 4 sketches the original data sources and structure of the UIFS4 dataset. Section 5 discusses the UIFS4 results by comparing these with the original source data. Section 6 gives the overall conclusions.

1. A systemic break in FDI statistics .....

In 1993, IMF published its *Balance of Payment Manual guidelines version 5*, further abreviated as BPM5. It defined FDI as a border-crossing capital investment by private firms that aims to obtain "a lasting say in the management" of the foreign firm through the acquisition of a substantial share –at least 10%– of the latter's voting stock (IMF 1993: 86).[7] Such investment may include the acquired equity stock, intra-company loan between parent company and foreign subsidiary, and reinvested earnings in years after acquiring the voting stock. Note that intra-company loans are included, but here the earmark element (obtaining a lasting say in the management) was essential. In the IMF perspective, all international equity-related investment where the element of management control is absent, is labelled portfolio investment. We quote the relevant BPM5 phrasing in full, because it was here that a big shift in FDI definition took place after 2008:

> "*The direct investor seeks a significant voice in the management of an enterprise operating outside his or her resident economy. To achieve this position, the investor must almost invariably provide a certain, often substantial, amount of the equity capital of the enterprise. The direct investor may also decide to supply other capital to further enterprise operations. Because of the direct investor's special relationship to the enterprise, his motives in supplying capital will be somewhat different from those of other investors. Thus, the capital supplied by a direct investor will probably exhibit characteristic behavior.*" (IMF, 1993: 81-82). And: "*The lasting interest implies the existence of a long-term relationship between the direct investor and the enterprise and a significant degree of influence by the investor on the management of the enterprise*" (IMF 1993: 86).

The crux of the FDI relation in BPM5 is hierarchical control[8] and the economic decision power that is associated with it. The key element of FDI statistics (as measured by BPM5) is that it displays the direction of hierarchical management control between countries: *what national quantity of firm assets is steered by parent companies from which national control center?* Financing plays a secondary role for FDI; intra-company loans from the parent company form just one of the applied control elements. Intra-company debt traffic is dominated and overshadowed by the FDI parent's equity-based control over the subsidiary's assets. BPM5 was very explicit about intra-company debts as part of FDI investment: "*Both loans to subsidiaries from direct investors and loans from subsidiaries to direct investors are included*" (IMF, 1993: 87-88), i.e. the control element prevails even if the multinational temporarily borrows from a subsidiary; the parent controls the

[7] "*Ownership of 10% or more of the voting power in an enterprise in one economy by an investor in another economy is evidence of such a relationship*" (OECD, 2015a; IMF, 2015a). In the USA, a 10 percent ownership of equity by a single foreign owner is deemed sufficient to make a U.S. firm considered as foreign in U.S. economic statistics (Graham and Krugman, 1989).

[8] In IMF jargon, the hierarchical management control is called the "directional principle".

subsidiary's management.[9] Of course, subsidiaries of multinationals also attract external financing from third parties. But this plays no role for the hierarchical control relation with the foreign parent company, even though locally-attracted finance is often considerably large.[10] Using more local financing often results in larger 'real' activities so that it may even extend the scope of the parent's control.

Things changed in the year 2008, the year of the Lehman Brothers collapse. It started the largest financial crisis that most OECD countries had experienced since the 1930s. Several large banks were being nationalised to prevent a full-scale financial breakdown. It was an "all hands on deck" situation: *"The key challenge is to break the downward spiral between the financial system and the global economy"* (IMF, 2009b: vi). In 2008-2009, financial authorities had developed a general anxiety for any further financial skeletons in the cupboard, especially hidden liabilities and unvisible asset writedowns of large, multinational firms:[11] "*Wide-ranging efforts to deal with financial strains in both the banking and corporate sectors will also be needed in emerging economies. Direct government support for corporate borrowing may be warranted. Some countries have also extended public guarantees of bank debt to the corporate sector and provided backstops to trade finance. Additionally, contingency plans should be devised to prepare for potential large-scale restructurings if circumstances deteriorate further*" (Blanchard and Viñals, 2009). In OECD and IMF, the discussion focused on achieving more transparency on intra-company, border-crossing financing relations. Special attention went to intra-company banking hubs and special-purpose entities that facilitate capital transfers.[12] After considerable discussion, both organisations decided to achieve this transparency *by changing the definition of FDI*, a fact that has slipped public attention and that also failed to attract appropriate alertness of most international economists. OECD and IMF decided that the provision of loans between fellow companies (subsidiaries within the same parent companies, but located in different countries) would in the FDI statistics be considered as fully equivalent to the 'traditional' FDI. Till then, FDI was exclusively based on the element of hierarchical management control. The new IMF's *Balance of Payment Manual guidelines* (BPM6) that codified this approach appeared in 2009, but it lasted until 2013 before its full consequences became generally applicable.[13] In the new IMF guidelines one reads about the watered-down FDI definition:

> *"As well as equity (which is associated with voting power), the direct investor may also supply other types of finance, as well as know-how. Direct investment tends to involve a lasting relationship, although it may be a short-term relationship in some cases"*

[9] Only for a minority-owned subsidiary, it would be necessary to correct for the non-owned part of the subsidiary's equity (treating the equiivalent part of the loan as an arm's length financing transaction).

[10] Lehman et al. (2004) found for US multinationals that equity, reinvested profits plus intra-company loans often contribute only less than one third of the total capital of foreign affiliates. For foreign affiliates in Finland, Leino and Ali-Yrkko (2014) found that equity, reinvested profits plus intra-company loans mostly formed less than half of the capital of these affiliates.

[11] See also, Lane and Milesi-Feretti, 2011; Forbes and Warnock, 2012; Caballero and Simsek, 2020; Coppola *et al.*, 2021.

[12] E.g. Working Group on International Investment Statistics (2008); Sola (2008). Also IMF (2008): "BPM6 [..] separately identifies the other financial corporations [*other than banks, HK*]. Given that these financial corporations have been increasing in size and importance, and given that they are less regulated than deposit-takers, considerable exposures can build up in this sector".

[13] Similar standards were almost simultaneously introduced by OECD (called Benchmark Definition 4, or shortly, BMD4) and Eurostat.

(IMF, 2009a: 101). *"Although debt and other claims that do not involve voting power are not relevant to defining a direct investment relationship, they are included in direct investment transactions and positions if a direct investment relationship exists between the parties."* (IMF, 2009a: 105, Note the peculiar tautology in the final sentence).

The changes (""*it may be a short-term relationship in some cases"*) are less innocent than they seem to be. The implication: if the parent company in country A asks for a loan from its subsidiary in country B, the full amount of this loan will from now on be reported as a *reverse* FDI, i.e. as *outward* FDI from country B going to country A.[14] Under the previous balance of payments guidelines (BPM5), this would *not* have been considered as a bilateral FDI transaction, or only as a change in the net financing structure of the subsidiary in country B. Note that this definition-led artificial FDI inflation happens without any matching increase of equity-related control from the subsidiary vis-à-vis its parent company in country A.

The change in FDI definition, mainly driven by anxiety for financial stability of OECD countries, has created a major inconsistency in FDI statistics that persists until today. And, due to the cumulative nature of FDI stocks, the inconsistency tends to become larger each year when multinationals use additional countries for setting up sub-holdings and financing hubs. Inconsistent, because it clearly deviates from the directional principle as defined in BPM5. The latter had a single organizing principle for bilateral FDI statistics and for making a distinction between direct investment and portfolio investment. BPM6 in fact introduced *two* organizing principles. The financial dependency between the loan provider and the loan receiver (within the same parent company) is given the same status as hierarchical management control based on equity ownership. Bilateral FDI statistics no longer measure the parent's equity-based control over a foreign subsidiary's assets, but they may as well measure intra-company loan traffic that has nothing to do with hierarchical management control. Stated otherwise, FDI statistics under BPM6 are polluted by intra-company financial transfers that have nothing to do with equity-based asset ownership. This change fully materialised in 2013, but some countries already applied the guidelines from 2010 onwards.

The crux of the system break is in the implementation rules, which ask from the national compilers of bilateral FDI statistics to *ignore any knowledge of indirect equity-based asset control by an ultimate parent company* that it is located in a third country. Take the case that the parent company in country A asks its finance hub in country C –based on its hierarchical say in management– to provide a loan to the fellow subsidiary in country B. The full amount of this loan transaction must from now on be registered as an outward FDI from country C into country B, *even if the compilers of the bilateral statistics would know that in fact it is an indirect investment from country A to country B*. The case that we sketch is not at all rare. It forms a dominant case for intra-company financing hubs, within-company treasuries and regional subholdings that are located in one of the

[14] The implications become more complicated when one or more intermediary intra-company financing hub are involved that are located in a third countries (C). Each additional intermediary country hub may then becom an additional source of double-counting, and therefore from the perspective of BPM5, of non-attributable fake-FDI.

world's offshore finance centres. This new statistical practice has lead to a huge inflation of inward and outward FDI.[15]

The introduction of BPM6 was preceded by serious discussion. We provide a brief summary of the major concerns that were voiced in this process, but that were eventually overruled due to fear for a financial breakdown. In the IMF Committee on Balance of Payments Statistics (BOPCOM) there was opposition from, *inter alia*, the European Central Bank and The Netherlands.[16] The predicted surge of negative values in bilateral FDI statistics formed the reason for much debate before the BPM6 rules were adopted at the end of 2008.[17] The new FDI definition would make it more difficult to interpret FDI statistics, because there is no intuitive explanation for negative FDI stocks. A further critique point was that the error percentage of bilateral FDI statistics would probably increase, also between country groups (e.g. offshore financial centres versus other countries). National compilers of FDI statistics need a lot of information (ownership, type of expenditure, role of financing constructions and special-purpose subsidiaries) for assessing a particular border-crossing transaction as foreign direct investment. The FDI definition under BPM6 would further complicate the task of national compilers, because equity ownership is no longer their sole guide. They must also look at financing dependencies (and ignore prior equity-based asset control). Wrong classifications and double counting would thus become more common. A further implication of the BPM6 guidelines is that the symmetry between inward and outward FDI data gets completely lost, because the loan-traffic-that-is relabelled-as-FDI leads to systematic double counting. The loss of symmetry between reported inward and outward FDI statistics implies that one loses an important consistency check on world FDI statistics.[18] Another point of critique was that the new FDI definition would hinder the comparison of FDI data with domestic investment expenditures by non-multinational firms (Claassen and Van der Dool, 2013:16-18). Other criticised the BPM6 definition change, because FDI data could no longer be used as yardstick for the relative investment attractiveness of countries (Sola, 2008). With the benefit of hindsight we may say that all these predictions were correct, but they were overruled in the 2008 cris atmosphere.

Management decision theory also suggests that the OECD/IMF-inspired break in FDI statistics is mistaken and should be corrected. In the normal business practice of firms, the decision to locate a particular investment in one country or another *precedes* the financing decision. Financing is of a different, mostly subordinate order, because

[15] As will be shown in Section 5. Cf. Zoromé (2007); Claassen and Van der Dool (2013); Pogliani *et al*. (2022). Bolwijn et al. (2018) estimate that 30-40% of total FDI stock is routed through investment hubs.

[16] E.g. IMF (2008). A recent IMF BOPCOM paper states: "*Complex financing and ownership structures of multinational enterprises can "inflate" direct investment (DI) flows and positions as each flow into and out of each economy is counted even if the funds, or income, is just passing through. This can make it difficult to interpret DI statistics and does not provide information on the ultimate sources and destinations of DI when the statistics are compiled by immediate partner economy*" (Kothe *et al.,* 2022: 2).

[17] BPM5 did not require netting of loans between fellow companies, but under BPM6 that has become the standard. The netting practice forms the reason for the increasing incidence of negative bilateral FDI stocks, something that was quite rare when the asset-centered FDI definition under BPM5 still prevailed.

[18] "*The application of the 'extended directional principle' changes the existing symmetry between inward and outward FDI. In the BMD3, every inward transaction in one country was related to an outward transaction in the counterpart country. In BMD4 it may happen that the two involved countries both record the same transaction/position in outward [..] FDI*" (Working Group on International Investment Statistics, 2008:6).

financing normally may be attracted from several sources, which are completely exchangeable (fungible). The decision to take a controlling influence in existing foreign production capacity or set up new real investments in another country is *not* fungible, but it forms a strategic development step for a firm. The BPM6 FDI definition implies that the difference beteen FDI and other items of BoP capital account (portfolio investments, 'other investment') became smaller.[19] Intra-company finance transactions that result in an increase of foreign liabilities are now registered as incoming FDI, even when there is no change in voting stocks or any other change in corporate control. The BPM6 statement "*As well as equity (which is associated with voting power), the direct investor may also supply other types of finance, as well as know-how"* (IMF, 2009a:101) fully misses the non-fungibility and control issue that goes together with real hierarchical FDI relations. Likewise, phrases like "*In the directional presentation, reverse investment can be seen as equivalent to the withdrawal of investment*" (IMF, 2009a: 108) are incorrect, because taking a loan will never be equal to selling equity that allows hierarchical management control. The importance of the control element of FDI is time and again found in empirical research, e.g. in the literature on vertical supply chains.[20] Our conclusion is that IMF/ OECD have deliberately introduced a system break in FDI statistics. The implication is that FDI statistics have become time-inconsistent and full of ambiguity. After BPM6, FDI is no longer strictly related to management control over assets that control production capacity.

All taken together, the BPM6 guidelines may have brought more insight in intra-company financial liabilities via a changed setup of the balance of payments, but at the price of low-quality, ambiguous FDI statistics. The key theoretical problem with current FDI statistics is that they have lost their prime focus: they can no longer be regarded and trusted as quantifiers for management-control relations between firms in different countries. The key statistical hurdles are: time inconsistency, double counting, loss of bilateral mirror symmetry, and over-reporting of bilateral flows. Under BPM5, FDI statistics could be accepted as one of only a few plausible and generally available quantifiers of multinational firm activity.[21] Now they have lost this unique selling point and thus have become unreliable. In a review article on current macro-economic research, Glandon *et al.* (2023) stress that feedback between theory and measurement is the key way forward for mature quantitative sciences. Current FDI time series have become largely unfit for testing any scientific hypothesis about international investment between hierarchically related firms.

[19] Cf. Lipsey, 2010; Lane, 2017; Adler *et al.*, 2019; FitzGerald, 2018.

[20] E.g. Adarov and Stehrer (2021) and Martínez-Galán and Fontoura (2019).

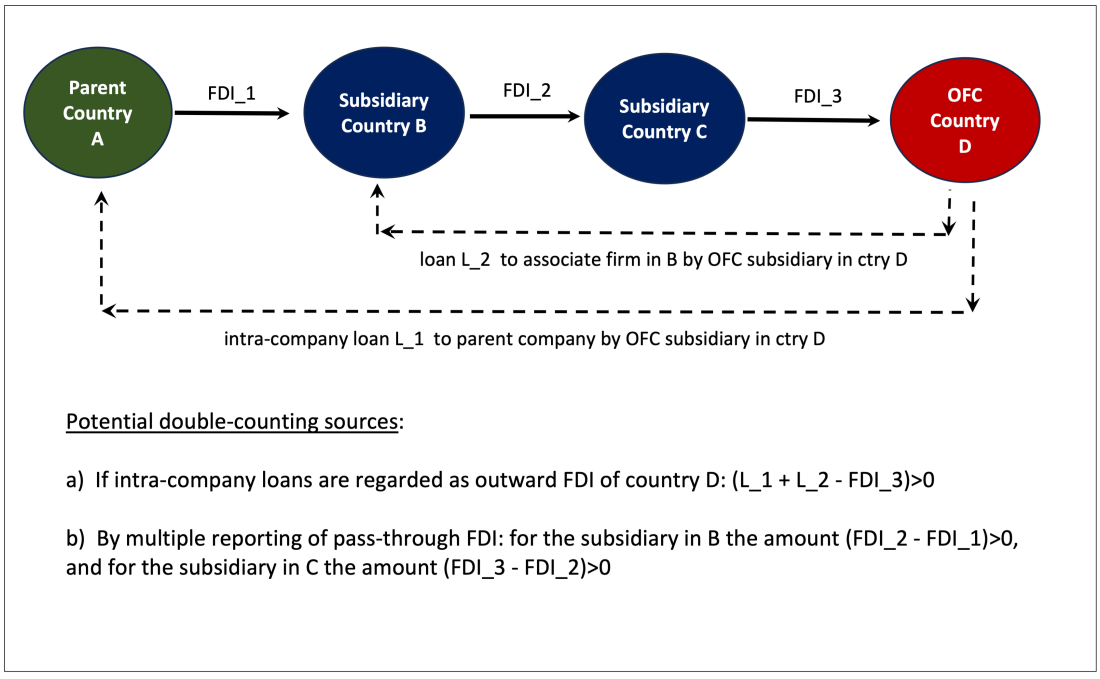
[21] Other sources are Eurostat's *Foreign Afiliate Trade Statistics* (FATS) and the US Bureau of Economic Analysis' *Acitivities of US Multinational Enterprises and Outward Direct Investment Positions by Country*. The first of both is only available for a limited number of countries and years, while the latter are only available for the USA. More micro-oriented data, such as those of Orbis, or fDI Markets (of the Financial Times) have drawbacks regarding international comparability, incompleteness (geographical bias), and non-verifiability.

2. … and how to repair it

Bilateral FDI often is reported twice. Each partner country –mostly independently– reports the magnitude of this amount. It means that in many cases mirror data are available. The good news about post-2009 FDI statistics of IMF (CDIS), OECD and Eurostat is that they offer more detailed statistics. This allows to unravel some components of bilateral FDI (assets, debts), and to choose a selective reading that is primarily asset-based, and therefore closer to the old-time FDI series (BPM5 statistics, before 2009). We may use the opportunities for selective interpretation of mirror data in case of bilateral FDI, in order to proxy the FDI definition of BPM5. Before describing the process we give the basic assumptions that underlie this reconstruction.

The upshot of the preceding section is that FDI statistics are 'polluted' by two types of over-reporting (double-counting) at micro-level. The first source is that intra-company loans by offshore finance hubs within the same multinational are regarded as outward FDI (after introduction of BPM6). The second source is that special-purpose entities (SPEs) with an intra-company holding or pass-through function report the nominal value of their outward FDI, without reporting the (full) value of the associated inward FDI that they received from the ultimate parent company. Damgaard *et al.* (2019, 2024) coined the name "phantom FDI" for such FDI that can no longer be attributed to individual countries. For a fictive case, Figure 1 elucidates both sources of phantom FDI, under the simplifying assumption that the subsidiaries do not attract local capital.[22]

Figure 1 Sources of phantom FDI, for a fictive case



[22] Without locally attracted finance in countries B and C, outward FDI between country A and D would under BPM5 have been equal to $FDI_3 - L_1$, while outward FDI of country D would have been zero. Under BPM6, outward FDI of country D equals $(L_2 + L_1)$.

FDI transactions pass through several measuring points (like central banks, national statistical organisations, government authorities) that potentially generate information on the FDI transaction. In the overwhelming majority of cases, FDI goes directly from the origin country to the immediate partner country. It may be the case that only one of two partner countries reports the (full) value of the bilateral transaction, whereas the other country reports nothing, or reports that the information is (partly) suppressed for confidentiality reasons.[23] In the case of confidentiality, the reporting country usually adds the relevant bilateral FDI amount to a category "Other countries" or "Unspecified". In such cases, the reported data of partner countries become an alternative source of information. This is called mirror data, because the symmetry principle (prevailing under BPM5) requires that outward FDI of one country must be more or less equal to inward FDI for its partner country. Using reported mirror data may thus leads to a more complete bilateral picture that defies data suppression for confidence reasons.

Bilateral FDI stock data are more widely available than FDI flow data. Bilateral FDI stocks are less volatile and –when asset-based– always semi-positive. The bilateral FDI flow tend to have strong annual fluctuations and a frequent occurrence of negative values, particularly associated with changes in intra-company loan positions and asset valuation changes. Moreover, FDI stocks have a consistent theoretical interpretation,[24] which is absent for FDI flows. Once using bilateral FDI stocks, it is always possible to derive first differences (annual changes), when necessary.

Verified zeros in bilateral FDI patterns are important information carriers. They signal the presence of large investment obstacles (e.g. Helpman *et al.*, 2004). Many countries pairs have never had outward bilateral direct investment. It means that none of their domestic firms found it profitable to invest in other countries. Many of the empty bilateral data cells are in fact most probably zero, e.g. between small and remote countries. Nonetheless, we will refrain from substituting missings by zeros, so as to respect the integrity of the original source data .

Following Clausing (2016), we preferably use equity-based bilateral FDI data to avoid double-counting and pollution of FDI data by financing constructions. However, not all bilateral FDI stocks are specified in terms of their composition (equity, reinvested profits and intra-company loan positions). Changes in the annual valuation of the financing component or a parent companies withdrawal of profits that were earlier reinvested in the subsidiary, could yield negative values from one year to another. Under BPM5, negative FDI stocks was no serious issue, though it ofted occurred in FDI *flow* statistics.[25] But under BPM6 it happens much more frequently. The original source data that we will be using, contain about 3-5% negative values for bilateral FDI stock in a particular year.

[23] The confidentiality suppression mostly takes place if publication would reveal the magnitude of the capital assets of a single company or a small group of companies. Also, national security reasons may be at stake.

[24] In particular the knowledge-capital theory of FDI (e.g. Markusen, 2002; Anderson et al., 2019; Kox and Rojas, 2020; Kox, 2024a; Davies and Markusen, 2024).

[25] OECD (2024) mentions three reasons why annual FDI flows may be negative: "First, if there is disinvestment in assets [..]. Second, if the parent borrowed money from its affiliate or if the affiliate paid off a loan from its direct investor. Third, if reinvested earnings are negative. Reinvested earnings are negative if the affiliate loses money or if the dividends paid out to the direct investor are greater than the income recorded in that period".

Even negative equity components occur, although this has been hotly debated.[26] The crux of the IMF (BPM5) definition of FDI is that a company has obtained a *lasting influence in the management of a firm in another country* through the ownership of equity or other real assets, and it is notably hard to conceive a negative 'lasting influence in management'. BPM6 implied that compilers of FDI statistics now got to deal with the principle that "*The equity value of an enterprise represents the value that remains for shareholders once all debts have been paid*" (Borga, 2019). But the structure of debt-financed international investments is heavily impacted by fiscal motives and tax-routing decisions. Most national systems of corporate income taxes have a bias that favours debt-based financing above equity-based financing.[27] The intra-company loan activity gave rise to a preference for debt-based financing over equity-based financing. For FDI statistics this has resulted in considerably more reported negative FDI stocks. To obtain time-consistent FDI statistics according to the BPM5 standard, it is necessary to correct such negative FDI stocks.[28] A selective interpretation could reduce the prime difference between BPM5 and BPM6 in the case that a parent company takes a loan from a foreign subidiary. Under BPM6, the amount of that loan is considered as an inward FDI stock and hence as an increase in foreign FDI liabilities ('*debts*') for the parent's country. By contrast, under BPM5 the same transaction would have been considered as a reduction of foreign FDI *assets* for the parent's country. In the BPM5 perspective, negative values of FDI stocks form a finance-related anomaly (cf. IMF, 1993: 87-88). In our reconstruction of BPM5-conform statistics we do not replace negative values by a zero, but by a 'missing'. The reason is that is that zero is a powerful statement, while we do not have enough information to justify it.

As a default rule we assume that bilateral FDI is –in most countries– more likely to be under-reported rather than over-reported.[29] There are several reasons for that: the presence of reporting thresholds in many countries; the presence of secrecy policies in some jurisdictions; the presence of tax-routing; the use of trust offices to hide firm ownership; and the role of limited capabilities and experience in national authorities (especially in the poorer countries) for dealing with often complex FDI transactions that may involve many countries. However, this default rule for conflicting mirror data is

[26] The report *Outcomes of the OECD Working Group on International Investment Statistics survey on negative equity*, published as annex in IMF (2024) reveals that some OECD member countries applied zero as minimum for FDI stocks, while others allowed negative FDI stocks.

[27] National systems of corporate income may allow tax deductability for interests paid on loans, but not for returns to equity capital. This asymmetry distorts corporate finance decisions: corporations prefer debt financing over equity financing beyond the level which they would otherwise have chosen. Moreover, it made it attractive to use intra-company finance affiliates that lend from low-tax countries to finance entities in high-tax countries, or by locating external borrowing in high-tax countries (cf. Keen and De Mooij, 2016).

[28] Elkjaer and Anacki (2023) propose these cases to be set to zeros, arguing that most multinational firms have a legal form in which the value of FDI stock cannot drop below the value of their limited-liability equity. They allow for exceptions in case the parent or affiliate has given guarantees for debt repayment. A similar position was in 2019 chosen by the European Central Banks. In the ensuing discussion it became clear that many national compilers of FDI see no possibilities for checking such guarantees, while other argued that many FDI companies have no limited-liability legal form. It remains to be seen what IMF's upcoming BMP7 standard will say about this issue (cf. IMF, 2024).

[29] Beugelsdijk et al. (2010) and Casella et al. (2023) find evidence that FDI stocks tend to understate the role of foreign corporate control over 'real' activities in those countries where it is easy to raise local capital. This effect does not hold for offshore finance centres, which often host only limited 'real' activities.

mitigated by a set of positive and negative decision rules in cases where we have several, diverging bilateral FDI measurements:

a) A negative rule is that all values reported by reputed offshore finance centres and tax havens will get a lower priority ranking, given their BPM6-related upward bias in bilateral FDI statistics;
b) given the cumulative nature of FDI stocks, reported values that would imply a sudden large shock (a year-on-year rise of >100%) are suspect and therefore get a lower priority ranking;
c) countries that score high on the World Bank indicator for statistical capabilities get a higher priority rank, provided that they are not reputed offshore finance centres or supposed tax havens;
d) countries that report asset-specific bilateral data get a higher priority ranking;
e) otherwise, we apply the default rule that in case of conflicting data on bilateral FDI we take the reported higher value.

A substantial part of bilateral FDI stocks forms part of complex network structures. Alabrese and Casella (2020) estimate that around 40% of all foreign affiliates form part of complex company structures in which the immediate investor is not the ultimate parent company. To answer the key BPM5 question (*what national quantity of firm assets is steered by parent companies from which national control center?*) we must know the ultimate origin country (UOC), which mostly is where the headquarter of the multinational is located. Similarly, we must know what the ultimate host country (UHC) is, where the effective operational subsidiary is operating. Real profit flows mostly move in the opposite direction. From a BPM5 perpective, all the rest of the complex network structures is of secondary importance. That includes the facilitating units, trust offices, intra-company financing hubs, or other 'special purpose entities' (SPEs) in pass-through countries, secrecy havens that offer multinationals a low-transparency climate for regional sub-holdings, and countries that open their network of bilateral tax treaties to tax-avoiding multinationals.[30] So, what we really want to know is the real FDI stocks between the ultimate origin country (UOC) and the ultimate host country (UHC). The inconvenient truth is, however, that this is not yet possible on the basis of the available source statistics. Most current FDI statistics report only about FDI traffic with the *immediate* partner country (IMC). However, experimental OECD data (OECD, 2015c) demonstrate that the disturbing role of all 'intermediary countries' is very locally concentrated, associated in particular with offshore finance centres in a limited number OECD countries.[31] By identifying and quantifying the role of FDI inflation by offshore

[30] The methodology of tax avoidance is reviewed in, *inter alia*, Dharmapala (2014), Clausing (2016), Dowd *et al*. (2017), Cobham and Janský (2019), Ates *et al.* (2021), Borga and Caliandro (2018) and Garcia-Bernardo and Janský (2024). There are extreme forms, such as round-tripping in which foreign fiscal constructions are used to eventually re-label domestic profits as inward FDI (e.g. Coppola et al., 2021; Qian et al., 2024).

[31] They identify eight countries where the use of immediate partner's data causes a more than 100% under-estimation of their real (UOC) impact: Great Britain, Canada, USA, Netherlands, Switzerland Luxemburg, France and Germany. And for another nine countries the under-estimation of their UOC-impact is between 50 and 100%: Sweden, Japan, Italy, China, Belgium Ireland, Russia, Mexico and Austria. For all other countries, the IMC-based data give a fairly good approximation of their real UOC-impact.

finance centres most of the bias problem will be removed.[32] Using immediate partner country (IMC) data for all remaining countries is then no longer causing a large bias.

3. Formal framework for worldwide bilateral FDI stock matrices[33]

The world FDI matrix basically has a simple structure. It describes equity-based FDI stock ownership relations for country pairs.[34] Let a_{ijt} be the cumulative value of investments that is owned by firms from country *i* in country *j* in the year *t.* Each element a_{ijt} can either be semi-positive (≥ 0) or missing ("."). Suppose the world has *n* countries, and firms can also invest in their own country.[35] The world FDI matrix then has the following structure:

$$\boldsymbol{W_t} = \begin{bmatrix} a_{11t} & a_{12t} & \cdots & a_{1nt} \\ a_{21t} & a_{22t} & \cdots & a_{2nt} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1t} & a_{n2t} & \cdots & a_{nnt} \end{bmatrix} \quad (1)$$

On the diagonal $[a_{11t}\ a_{22t}\ \ldots\ a_{nnt}]$ we find what firms invest in their own country. If we disregard these domestic investments and only focus of border-crossing investments, there remain (n-1) elements in each row and column, so $(n-1)^2$ in total. All countries potentially invest in each other. If each matrix element identifies an uni-directional bilateral FDI stock, the matrix holds two elements per country pair. Take for example the country pair {*2, n*}. One element a_{2n} quantifies for reporting country "2" the outward FDI stocks from its firms that go to country "*n*", while element a_{n2} quantifies for reporting country "*n*" how much outward FDI stocks it has in country "*2*". The matrix treats both types of bilateral stocks as separate; there is no 'netting' of both uni-directional stocks. We may now derive the matrix $\boldsymbol{OW_t}$ of outward FDI stocks per reporting country:

$$\boldsymbol{OW_t} = \begin{bmatrix} 0 & a_{12} & \cdots & a_{1n} \\ a_{21} & 0 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 0 \end{bmatrix} \quad (2)$$

Note that the diagonal of strict domestic investments $[a_{11t}\ a_{22t}\ \ldots\ a_{nnt}]$ now holds zeros. For brevity of notation we have suppressed the time suffices within the matrix brackets. Similar to $\boldsymbol{OW_t}$ we may formulate the matrix $\boldsymbol{IW_t}$ of inward FDI stocks per reporting country:

[32] Beck *et al.* (2024) document the outsized role that Luxemburg, Netherlands and Luxembourg have for Euro Area financial statistics generated by their dual roles as hubs of financial intermediation and as places of securities issuance.

[33] This section may without problems be skipped by readers that prefer a more verbal description. The construction of the dataset, its source data and its results are described in Sections 4 and 5.

[34] We strictly follow the consistent FDI interpretation that follows from the IMF's BPM5 guidelines and the seven basic assumptions (pillars) that were described in Section 2.

[35] The latter is measured in the domestic capital accumulation account, not in the balance of payments.

$$\boldsymbol{IW_t} = \begin{bmatrix} 0 & b_{12} & \cdots & b_{1n} \\ b_{21} & 0 & \cdots & b_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ b_{n1} & b_{n2} & \cdots & 0 \end{bmatrix} \quad (3)$$

Each element b_{ij} quantifies the cumulative value of foreign investments into reporting country *i* that originates from or is owned by firms from country *j*. Each element represents an uni-directional ownership relation, so that also $\boldsymbol{IW_t}$ holds two elements per country pair $\{b_{ij}\ ,\ b_{ji}\}$.

There should be a correspondence between $\boldsymbol{OW_t}$ and $\boldsymbol{IW_t}$. In a world with perfect data, the reported outward FDI of country *j* would be equal to the reported inward FDI of country *i*, so that:

$$a_{ijt} \rightleftarrows b_{ijt} \quad (\forall\ i \neq j) \quad (4)$$

In that world with perfect data, it would be sufficient to have one of both values for each bilateral FDI transaction. However, the perfect-data condition (4) does not apply for world statistics on bilateral FDI. The main imperfections are:[36]

- systematic errors, such as BPM6-based distortions (taking loans from a parent company is a financing transaction and not FDI, because it has nothing to do with the direction of hierarchical control within the multinational company);
- differences in data-compiling systems by international organisations (mainly IMF, UNCTAD, OECD, Eurostat), including differences in the way they estimate under-reported components of bilateral FDI stocks;
- intentional obscuring of FDI ownership relations, legal masking of FDI-related transactions via 'special purpose entities' (SPEs) or via sub-holdings in low-transparancy jurisdictions where the multinational company has no real business activity;
- confidentiality-related data suppression by one or both partner countries;
- different reporting or data-compiling standards, or different registration thresholds by one or both partner countries;
- random reporting errors such as dimension errors, non-consistent exchange rate conversion and/or aggregation errors.

The imperfections make it advisable to treat the "true" value of the elements a_{ijt} and b_{ijt} as a non-observed latent variable. These latent variables for bilateral FDI stocks can only be approximated if we use all available reported data, in both matrices $\boldsymbol{OW_t}$ and $\boldsymbol{IW_t}$, based on reports by each partner country and by each international provider of FDI statistics.

Before dealing with the procedure that we followed in the construction of the UIFS4 database it is necessary to specify a particular data imperfection that frequently occurs. Many countries provide only a partial bilateral specification of their FDI stocks. The specification horizon often differs by country, year, and often also for inward and outward FDI stocks. Let k_{it} be the last country for which outward FDI is bilaterally

[36] The imperfections could result in a low pairwise correlation between a_{ijt} and b_{ijt} data for bilateral FDI stocks per country pair.

specified, while v_{it} is the corresponding parameter for inward FDI. The rest-of-the-world residuals for reporting country *i* are labelled, respectively, as ROW_{it}^{in} and ROW_{it}^{out}. Suppressing time indices, they are defined as:

$$ROW_{it}^{out} = a_{i,k_i+1} + a_{i,k_i+2} + .. + a_{i,n-1} \qquad if \quad k_i < (n-1) \tag{5}$$

$$ROW_{it}^{in} = b_{i,v_i+1} + b_{i,v_i+2} + .. + b_{i,n-1} \qquad if \quad v_i < (n-1) \tag{6}$$

The non-specification issue implies a further disturbance of the perfect data structure of eq.(4). Instead, we are in a situation that we have to start with outward bilateral FDI data that have the following structure (with time suffices suppressed):

$$\boldsymbol{OW}^{*} = \begin{bmatrix} 0 & a_{12} & a_{13} & \cdots & a_{1k_1} & ROW_1^{out} \\ a_{21} & 0 & a_{23} & \dots & a_{2k_2} & ROW_2^{out} \\ a_{31} & a_{32} & 0 & \cdots & a_{3k_3} & ROW_3^{out} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ a_{k_1 1} & a_{k_2 2} & a_{k_3 3} & \dots & 0 & ROW_k^{out} \\ a_{ROW,1} & a_{ROW,2} & a_{ROW,3} & \dots & a_{ROW,k} & 0 \end{bmatrix} \tag{7}$$

And similarly for inward FDI:

$$\boldsymbol{IW}^{*} = \begin{bmatrix} 0 & b_{12} & b_{13} & \cdots & b_{1v_1} & ROW_1^{in} \\ b_{21} & 0 & b_{23} & \dots & b_{2v_2} & ROW_2^{in} \\ b_{31} & b_{32} & 0 & \cdots & b_{3v_3} & ROW_3^{in} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ b_{v_1 1} & b_{v_2 2} & b_{v_3 3} & \dots & 0 & ROW_v^{in} \\ b_{ROW,1} & b_{ROW,2} & b_{ROW,3} & \dots & b_{ROW,v} & 0 \end{bmatrix} \tag{8}$$

The first task is to reduce to the proportions of the non-specification problem. Often, the mirror data reported by the partner country, form excellent alternative information for empty data cells. It is also useful to try and fill in data gaps with FDI statistics of other international organisations. Both steps increase the share of bilateral specified data (k_{it}, v_{it}) and reduce the non-specified part.

We describe the formal procedure for approximating the latent variables a_{ijt} and b_{ijt} by the use of reported and bilaterally specified data. The non-specified subaggregates (ROW_i^{in}, ROW_i^{out}) that were reported in the original source data, cannot be used in this process for the simple reason that they carry no bilateral information. From now on, all reported data will carry a hat (ˆ) accent. Each international organisation that publishes bilateral FDI statistics has its own statistical system integrity that has to be guarded in the mirroring operation. The approximation procedure starts with the statistics of data-publishing institution $q \in Q\{1,2,..,m\}$. Two potential data sources exist for each a_{ijqt} or b_{ijqt} element. Formally we have:

$$\begin{cases} \forall\, a_{ijqt} \triangleq^{m} \mathbb{R}_{+}: \left(\hat{a}_{ijqt}\,, \hat{b}_{jiqt}\right) \\ \forall\, b_{ijqt} \triangleq^{m} \mathbb{R}_{+}: \left(\hat{a}_{jiqt}\,, \hat{b}_{ijqt}\right) \end{cases} \tag{9}$$

in which the expression "$\triangleq^{m} \mathbb{R}_{+}$: " means "*..is measured by the set of real, semi-positive numeric observations* (...)". We may select a_{ijqt} by using either $\hat{a}_{ijqt}$ (stems from the outward FDI data of the reporting country, or $\hat{b}_{jiqt}$ (stems from the inward FDI data of

the partner country). The same procedure holds for the selection of b_{ijqt}. The choice rules in context of the q-specific statistics are as follows: (1) negative elements are replace by empty elements; (2) non-empty elements have precedence over empty elements; (3) strictly positive elements have precedence over zero elements; (4) asset- or equity-based positive elements have precedence over both debt-based elements and elements for which no composition is indicated in the q-specific data; (5) a lower priority ranking is given to data reported by a country that has a tax haven status, a non-transparancy status or the status of an offshore finance centre (OFC); (6) data reported by a country that h,as a higher ranking for statistical capabilities get a higher priority ranking. This procedure yields —for each of the m sets of original source data— the preferred $\{a_{ijqt}, b_{ijqt}\}$ plus an extended bilateral specification (k_{it}, v_{it}) per country pair.

The next step brings together the m prepared a_{ijqt} for filling the matrix ***OW**** (bilateral outward FDI stocks) and the approximation of the latent values of bilateral FDI stocks per country pair and year:

$$\forall\, a_{ijt} \triangleq^{\mathrm{m}} \mathbb{R}_{+}\colon \left(a_{ij1t}\,, a_{ij2t}\,, a_{ij3t}, \ldots, a_{ijmt}\right) \tag{10}$$

The selection and substitution rules now are slightly modified in line with the basic assumptions that were specified in Section 2. We apply a combination of generic selection rules and period-specific selection criteria. The generic selection rules are: (1) non-empty elements have precedence over empty elements; (2) strictly positive elements have precedence over zero elements; (3) data reported by a country that has a tax haven status, a non-transparancy status or an OFC status get a lower priority ranking; (4) data reported by a country that has a higher ranking for statistical capabilities get a higher priority ranking; and (5) source statistics that are compiled under the BPM5 guidelines have preference over source statistics that are compiled under BPM6.[37] The period-specific selection rules are based on the country coverage of the source data, their documentation quality, the completeness of their FDI stock decomposition, their use of verified or confirmed zeros; their documentation of confidentiality-based suppression of bilateral data.

The filling of matrix ***IW**** (bilateral inward FDI stocks) and the approximation of the latent values of FDI stock volumes proceeds in the same way:

$$\forall\, b_{ijt} \triangleq^{\mathrm{m}} \mathbb{R}_{+}\colon \left(b_{ij1t}\,, b_{ij2t}\,, b_{ij3t}, \ldots, b_{ijmt}\right) \tag{11}$$

These steps yield two relatively independent matrices (***IW**^B*, ***OW**^B*), now with suffix ***^B*** to distinguish them from the matrices described in eq.(7,8) that contained a non-specified component. The new matrices are fully based on reported data in combination with the specified selection rules. The bilaterally specified component has again expanded (higher parameters k_{it}, v_{it}).

This process will continue in the next step where the information of both matrices will be combined, using the '*biproportional matrix balancing*' technique (Lahr and de Mesnier, 2004).[38] Our application of this technique uses ***IW**^B* and ***OW**^B* iteratively and

[37] This refers to the period 2008-2012 when overlapping statistics under both guidelines were compiled. Table 1 in Section 4 shows the overlap per set of source data.

[38] The technique is used, *inter alia*, in input-output analysis (e.g. Miller and Blair, 2009: Ch.7).

cyclically as source and as prediction. Mirror values per country pair ($a_{ijt} \leftrightarrow b_{ijt}$; $a_{jit} \leftrightarrow b_{ijt}$) refer to the same FDI traffic. We already used these linked matrix elements as a mutual predictor (eq.9).

This will now be done on a more 'industrial' scale, namely matrix-by-matrix. The procedure is that one of the matrices $\boldsymbol{IW^B}$ and $\boldsymbol{OW^B}$ is taken as basis. Starting with $\boldsymbol{IW^B}$, we transpose the matrix by switching rows and columns $[\boldsymbol{IW^B}]^{\mathbf{T}}$, so that each reporting country becomes partner country, and partners becomes reporting countries. This new matrix 'predicts' $\boldsymbol{OW^B}$. Then compare the actual $\boldsymbol{OW^B}$ and the predicted matrix $[\boldsymbol{IW^B}]^{\mathbf{T}}$ and analyse the differences; the latter hold possibly relevant alternative information. Then use a set of decision rules to use or reject this alternative information, thus creating a new version of matrix $\boldsymbol{OW^B}$. This new matrix, labelled $\boldsymbol{OW^2}$ can be used to start a new prediction and substitution cycle. Over successive cycles, the number of matrix elements with numeric information increases. Our experience was that four cycles are sufficient to absorb all relevant new mirroring information. Figure 2 summarises the full algorithm. The starting matrix of the cycle is marked with a 'hat' (ˆ) above the matrix name, and the transposed prediction matrix is marked by a tilde (˜) above the matrix name.

Figure 2 The mirroring algorithm for reported bilateral FDI stocks

step 1: $\widehat{\boldsymbol{IW^B}} \xrightarrow{mirror\ predicts} \widetilde{\boldsymbol{OW^1}}$

step 2: compare $\widetilde{\boldsymbol{OW^1}}$ with $\widehat{\boldsymbol{OW^B}}$: apply substitution rules $\xrightarrow{yields} \boldsymbol{OW^2}$

step 3: $\widehat{\boldsymbol{OW^2}} \xrightarrow{mirror\ predicts} \widetilde{\boldsymbol{IW^1}}$

step 4: compare $\widetilde{\boldsymbol{IW^1}}$ with $\widehat{\boldsymbol{IW^B}}$: apply substitution rules $\xrightarrow{yields} \boldsymbol{IW^2}$

step 5: $\widehat{\boldsymbol{IW^2}} \xrightarrow{mirror\ predicts} \widetilde{\boldsymbol{OW^3}}$

step 6: compare $\widetilde{\boldsymbol{OW^3}}$ with $\boldsymbol{OW^2}$: apply substitution rules $\xrightarrow{yields} \boldsymbol{OW^4}$

step 7: $\widehat{\boldsymbol{OW^4}} \xrightarrow{mirror\ predicts} \widetilde{\boldsymbol{IW^3}}$

step 9: compare $\widetilde{\boldsymbol{IW^3}}$ with $\boldsymbol{IW^2}$: apply substitution rules $\xrightarrow{yields} \boldsymbol{IW^4}$

step 10: $\widehat{\boldsymbol{IW^4}} \xrightarrow{mirror\ predicts} \widetilde{\boldsymbol{OW^F}}$

step 11: $[\widehat{\boldsymbol{OW^F}}]^{\boldsymbol{T}} \xrightarrow{mirror\ predicts} \boldsymbol{IW^F}$

After these steps, we have fully exhausted the information available in the set of reported inward and outward FDI stock values with full bilateral specification. The next step is dealing with partially specified FDI stock data (see eqs. 5-8). The problem is now that

the partially specified aggregates (ROW_i^{in}, ROW_i^{out}) of eqs.(7,8) came from the original FDI source data, and these have been partially overruled by the mirroring algorithm. So, we need a new set of plausible proxies for partially specified inward and outward FDI stocks per reporting country. We solve this by using external benchmark data for each country's annual total inward and outward FDI positions.[39] The approximation procedure of the partially specified annual FDI stocks ($XLG_{it}^{IN}, XLG_{it}^{OUT}$) is as follows:

$$XLG_{it}^{IN} = B_{it}^{EXT} - \sum_{i=1}^{v_i} b_{ijt} \quad ; \forall \left(B_{it}^{EXT} - \sum_{i=1}^{v_i} b_{ijt} \right) \geq 0 \tag{12}$$

$$XLG_{it}^{OUT} = A_{it}^{EXT} - \sum_{i=1}^{k_i} a_{ijt} \; ; \forall \left(A_{it}^{EXT} - \sum_{i=1}^{k_i} a_{ijt} \right) \geq 0 \tag{13}$$

in which B_{it}^{EXT} and A_{it}^{EXT} are the external benchmarks for each country's, respectively, inward and outward FDI stocks originating from the rest of the world. The second RHS term of both equations is the row sum of country *i*'s fully bilaterally specified FDI stocks (reported in, respectively, matrix $\boldsymbol{IW^F}$ and matrix $\boldsymbol{OW^F}$). Note that eq.(12) restricts XLG_{it}^{IN} to the real, semi-positive domain, i.e. XLG_{it}^{IN} may be zero, and the same holds in eq.(13). Cases where these non-negativity restrictions are violated, also occur (to be analysed later on).

Applying the row and column totals for FDI traffic that can only partially be attributed ($XLG_{it}^{OUT}, XLG_{it}^{IN}$), it is now possible to give the structure of the annual UIFS4 matrices for world outward FDI stocks ($\boldsymbol{OW^{TOT}}$) and inward FDI stocks ($\boldsymbol{IW^{TOT}}$), with time suffices suppressed:

$$\boldsymbol{OW^{TOT}} = \begin{bmatrix} 0 & a_{12} & a_{13} & \cdots & a_{1k_1} & XLG_1^{OUT} \\ a_{21} & 0 & a_{23} & \ldots & a_{2k_2} & XLG_2^{OUT} \\ a_{31} & a_{32} & 0 & \cdots & a_{3k_3} & XLG_3^{OUT} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ a_{k_1 1} & a_{k_2 2} & a_{k_3 3} & \ldots & 0 & XLG_{k_I}^{OUT} \\ XLG_1^{IN} & XLG_2^{IN} & XLG_3^{IN} & \ldots & XLG_{k_I}^{IN} & Z_w \end{bmatrix} \tag{14}$$

$$\boldsymbol{IW^{TOT}} = \begin{bmatrix} 0 & b_{12} & b_{13} & \cdots & b_{1v_1} & XLG_1^{IN} \\ b_{21} & 0 & b_{23} & \ldots & b_{2v_2} & XLG_2^{IN} \\ b_{31} & b_{32} & 0 & \cdots & b_{3v_3} & XLG_3^{IN} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ b_{v_1 1} & b_{v_2 2} & b_{v_3 3} & \ldots & 0 & XLG_{v_I}^{IN} \\ XLG_1^{OUT} & XLG_2^{OUT} & XLG_3^{OUT} & \ldots & XLG_{v_I}^{OUT} & -Z_w \end{bmatrix} \tag{15}$$

The structure of both matrices is fully mirror symmetric in the sense of eq.(4). However, there is no reason that the mirror symmetry would also hold for the last row and the last column of both matrices. In order to get balanced $\boldsymbol{OW^{TOT}}$ and $\boldsymbol{IW^{TOT}}$ matrices we add a residual element Z_w which represents the non-attributable differences between total semi-positive inward and outward FDI at world level in a given year. It is defined as:

[39] For details on the independent benchmarks B_{it}^{EXT} and A_{it}^{EXT}, see Section 4 on data sources.

$$Z_{wt} \equiv \sum XLG_{it}^{IN} - \sum XLG_{it}^{OUT} \tag{16}$$

This completes the formal description of the construction procedure for UIFS4 matrices. The matrices are strictly built on reported data. There is no imputation or estimation for missing data. The mirroring procedure allows to increase the share of bilaterally specified FDI stocks, while the selection and substitution rules allow to give priority to (reported) data that suffer less from the distortions, inconsistencies and double-counting that the BPM6 guidelines have introduced in international FDI statistics. This procedure diminishes the impact of the distortions, but does not eradicate them. After 2013 there are no real alternatives available for BPM6-conform FDI statistics. This means that each element ($a_{ijt} \rightleftarrows b_{ijt}$) may still hold the impact of the BPM6 distortions. Indirectly, via eq.(16), the effect of these distortions will "land" in non-attributable annual differences between total reported semi-positive outward and inward FDI stocks at world level (Z_{wt}).

We may use the formal framework of Section 2 to derive a few useful indicators of FDI over-reporting. Eqs.(12, 13) show that we may use the benchmark data to extract a few additional aggregates at world and country level. Let NAT_{it}^{in} and NAT_{it}^{out} be the annual amount of over-reported FDI stocks (repectively, inward and outward) per country, defined as:

$$NAT_{it}^{in} \equiv B_{it}^{EXT} - \sum_{i=1}^{v_i} b_{ijt} \quad ; \; \forall \left(B_{it}^{EXT} - \sum_{i=1}^{v_i} b_{ijt} \right) < 0 \tag{17}$$

$$NAT_{it}^{out} \equiv A_{it}^{EXT} - \sum_{i=1}^{k_i} a_{ijt} \; ; \; \forall \left(A_{it}^{EXT} - \sum_{i=1}^{k_i} a_{ijt} \right) < 0 \tag{18}$$

After imposing an orthogonality constraint on world FDI matrices ($\boldsymbol{OW^{TOT}}$and $\boldsymbol{IW^{TOT}}$), we may get a step further by investigating the contributions of individual countries to the world gap of non-attributable FDI stocks. Eq.(17,18) yield two useful operational ratio numbers. The first one is the relation between a country's non-attributable FDI stocks and their reported FDI stocks that could be verified using information of their partner countries. Let $dnatsh_{it}$ be the domestic share of non-attributables in reported FDI stocks. It can be calculated for outward and inward FDI stocks:

$$dnatsh_{it}^{inw} = \frac{NAT_{it}^{in}}{\sum_i^{v_i} b_{ijt}} \quad , \qquad dnatsh_{it}^{outw} = \frac{NAT_{it}^{out}}{\sum_i^{k_i} a_{ijt}} \tag{19}$$

For countries with small domestic economies and no activities in the offshore finance or in the tax-sheltering and tax-avoidance business, the $dnatsh_{it}$ ratios can expected to be close to zero. However, for small economies with lots of activities in these businesses we may expect ratios that are sky-high. All other countries will be somewhere in between.[40]

[40] To reduce the heteroskedasticity effects of such a large dispersion, we prefer to use the log of the $dnatsh_{it}$ ratio.

The second ratio measures a country's contribution to the world total sum of non-attributable FDI stocks; it is labelled $cwshar_{it}$. This can be done calculated for inward and outward FDI stocks:

$$cwshar_{it}^{inw} = \frac{NAT_{it}^{in}}{\sum_i^n NAT_{it}^{in}} \quad , \quad cwshar_{it}^{outw} = \frac{NAT_{it}^{out}}{\sum_i^n NAT_{it}^{out}} \tag{20}$$

4. Original source statistics for the UIFS4 dataset

We have only used FDI databases that are directly based on reported FDI stock values, thus refraining from using databases that are partly based on imputed values. The "4" in UIFS4 stands for the four main original sources that have been used in the construction of this database: IMF (*Coordinated Direct Investment Survey*),[41] OECD (*OECD International Direct Investment Statistics*), Eurostat (*International Investment Position Statistics*) and UNCTAD (*World Investment Report*).[42] The sources have different, but overlapping specialisations in FDI statistics. IMF and UNCTAD compile global statistics on FDI, whereas the focus of the OECD and Eurostat is on a narrower group of countries. Apart from these four main sources, we supplement the data with a number of smaller sources (ASEAN, World Bank, Asian Development Bank, national statistics). UNCTAD's *World Investment Report* aggregates national data on both FDI transactions and stocks. Because of the regime change in the compiling guidelines for FDI statistics that became fully effective after 2012, we distinguish pre-2009 statistics (BPM5 and its OECD equivalent BMD3) and post-2008 statistics (BPM6 and BMD4). Table 1 presents the structure of the available source data.

Table 1 Comparative structure of the original source data for the UIFS4 database, 2001-2022 (based on inward FDI stocks)

YEAR	Non-zero bilateral observations (in thousands)						Non-missing bilateral zero observations (in thousands)						Total number of non-missing bilateral observations (in thousands)					
	UNCTAD, BMP5	OECD, BMD3	Eurostat, BMD3	IMF, BPM6	Eurostat, BMD4	OECD, BMD4	UNCTAD, BMP5	OECD, BMD3	Eurostat, BMD3	IMF, BPM6	Eurostat, BMD4	OECD, BMD4	UNCTAD, BMP5	OECD, BMD3	Eurostat, BMD3	IMF, BPM6	Eurostat, BMD4	OECD, BMD4
2001	3,0	1,8	0,1				3,1	2,6	0,0				6,1	4,4	0,1			
2002	3,1	2,1	0,1				3,0	3,6	0,0				6,1	5,7	0,1			
2003	3,2	2,7	0,2				2,8	4,7	0,0				6,0	7,4	0,2			
2004	3,6	2,9	0,3				2,5	5,2	0,0				6,1	8,1	0,3			
2005	3,8	2,8	0,3			0,2	2,4	5,4	0,0			2,0	6,2	8,2	0,3			2,2
2006	4,0	3,2	0,3			0,2	2,3	6,3	0,0			2,0	6,3	9,5	0,3			2,2
2007	4,4	3,3	0,3			0,2	2,1	6,3	0,0			2,0	6,5	9,6	0,3			2,2
2008	4,4	3,4	0,9			0,5	2,1	6,4	0,0			2,6	6,5	9,8	0,9			3,1
2009	5,2	3,5	0,9	6,7		0,6	2,1	6,5	0,0	10,3		3,0	7,3	10,0	0,9	17,0		3,6
2010	5,7	3,7	0,9	7,4		0,6	1,7	6,6	0,0	12,4		2,9	7,4	10,3	1,0	19,8		3,5
2011	5,7	3,7	0,9	8,1		0,7	1,9	6,6	0,0	14,4		3,0	7,6	10,3	1,0	22,5		3,7
2012	5,4	3,7	0,9	8,5		1,0	1,9	5,7	0,0	14,9		3,3	7,3	9,4	1,0	23,4		4,3
2013		0,7		8,8	2,6	2,4		1,0		13,6	3,7	7,8		1,7		22,4	6,3	10,2
2014				9,0	3,2	2,4				13,7	4,9	8,4				22,7	8,1	10,8
2015				9,6	3,7	2,6				13,3	6,5	8,6				22,9	10,2	11,2
2016				10,0	3,8	2,9				14,3	6,3	8,9				24,3	10,1	11,8
2017				10,5	3,8	3,1				14,8	5,8	8,9				25,3	9,6	12,0
2018				10,8	4,1	3,1				15,0	6,1	8,6				25,8	10,2	11,7
2019				10,9	4,2	3,2				15,1	6,4	8,9				26,0	10,6	12,1
2020				10,8	4,1	3,1				14,5	6,5	8,7				25,3	10,6	11,8
2021				10,9	4,4	3,1				14,8	7,0	8,6				25,7	11,4	11,7
2022				10,4	4,3	2,9				13,6	6,9	8,1				24,0	11,2	11,0
TOTAL	51,5	37,5	6,1	132,4	38,2	32,8	27,9	66,9	0,2	194,7	60,1	106,3	79,4	104,4	6,3	327,1	98,3	139,1

[41] Cf. IMF (2015a, 2015b).

[42] UNCTAD published bilateral FDI statistics until 2012 (UNCTAD, 2014). Since then UNCTAD publishes national totals for inward and outward FDI stocks. They disregard data reported by financial centres in the Caribbean and special-purpose entities in reporting countries; instead, they estimate the FDI data for these countries, based on the size of their real economy, proxied by their GDP.

The source data from IMF, OECD, Eurostat and UNCTAD distinguish between verified zeros, confidentiality-suppressed missings, and non-missing bilateral observations. Some of the sources also notify when and why a particular bilateral value is suppressed for confidentiality reasons. In the case of 'confidentiality missings' we leave the bilateral data cell empty, unless the partner country reports a zero or a non-zero bilateral FDI stock.

The mirroring procedure (cf. preceding section) expands the number of data cells with semi-positive numerical information. Each of the four databases with orginal source data may to some extent have different data-compiling methods. Moreover, for most of the sources it holds that for each bilateral FDI stock the country that reports inward FDI may register a different value than the country that reports the outward FDI stocks. To handle such differences in the reported mirror data, we respect each source's specific data-compiling method. We therefore first apply, for each data source, the set of five decision rules for diverging mirror values per country pair.[43] Only after this process, we join the selected bilateral FDI values from the four original sources. It means that we may then have 2, 3 or even 4 different values for a particular annual bilateral FDI stock. We give precedence to the values reported by the largest data sources, separately for the BPM5 period and the BPM6 period. For the BPM5 period the priority ranking is: UNCTAD, OECD, Eurostat, IMF. For the BPM6 period the priority ranking is: IMF, Eurostat (for EU countries), OECD, Eurostat (other countries). The UNCTAD dataset of aggregate national FDI stocks is the most time-consistent dataset. It partly draws on national bilateral data. In the compiling stage, they directly remove data from jurisdictions with a known reputation for hosting many tax-related special-purpose entities (SPEs), and further they use their *implied investment method* (Bolwijn et al. 2018; Casella et al., 2023) and the IMF method (Damgaard et al. 2024, 2019) to estimate the real FDI stocks of the SPE jurisdictions based on the relation with FDI stocks and GDP. We use this UNCTAD dataset of aggregate national FDI stocks to derive each country's annual 'rest-of-the-world' residual, after having used all reported bilateral data in the mirroring algorithm.

The substitution algorithm that is used in the construction of the UIFS4 database (section 3) ranks priorities for alternative reported FDI values per country pair. One of the decision rules is the state of a country's statistical capabilities. For this we use the World Bank SPI indicator for statistical capabilities of countries, ranging from 0 to 100 (highest). The indicator assesses the maturity and performance of national statistical systems in five key areas (use of data use, data services, data products, sources of data, and data infrastructure).[44]

[43] As specified below equation (10) in Section 3.

[44] For methodology,see Cameron *et al*. (2019), and https://www.worldbank.org/en/programs/statistical-performance-indicators.

5. Results: comparing UIFS4 with its original source files

The resulting UIFS4 database has the structure of a balanced panel. With 232 countries and jurisdictions, the database holds 54,056 annual bilateral country pairs. This potentially yields about 1.2 million bilateral observations over a period of 22 years (2001-2022). However, 53% of all data cells is empty, meaning that no numeric value has been reported by any of the source files. For another 30% of the data cells, it was possible to identify confirmed zeros for the bilateral traffic. For 16% of all data cells we could assess reported positive values. So, overall the UIFS4 database contains 557,300 numerical values (46,7%).

Table 2 compares the UIFS4 database with its source files that all cover only a limited part of the 2001-2022 period. The absolute number of numeric-filled data cells is higher than any of the source files. In relative terms, only the Eurostat (BMD4) performs better than UIFS4, particularly by reporting almost 60% confirmed zeros, but for a total number of data cells that is one sixt of of UIFS4. The relative share of data cells with positive FDI values of UIFS4 is higher that any of the other databases except Eurostat.

Particularly for gravity-based FDI research, the number of confirmed zeros is of crucial importance for a proper assessment of real FDI barriers like remoteness, size, language, and policy-related obstacles. While the IMF and OECD source files reported many data cells where bilateral FDI vales were repressed for confidentiality reasons, the use of the

Table 2 Comparison between UIFS4 and its original source files, 2000-2001 ((based on inward FDI stocks)

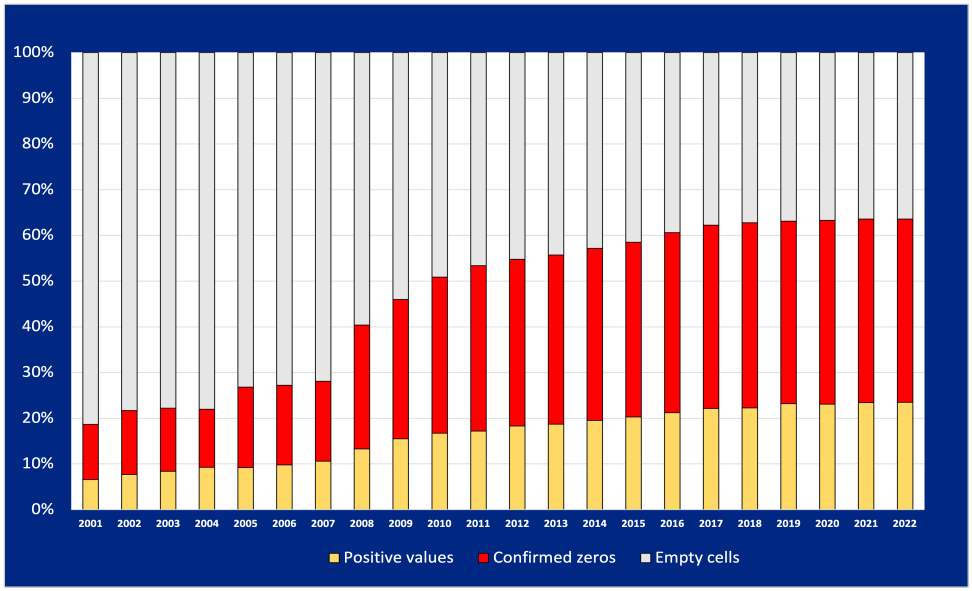
Database	Number of observations (x 1000)	% empty cells	% with zeros	% that is suppressed for confidence reasons	% with positive FDI data	No. of numeric-filled data cells (x 1000)	Mean annual value (mln USD)
UIFS4_FINAL	**1194**	**53,3**	**30,3**	**0,0**	**16,4**	**557,3**	**1062**
Source files:							
UNCTAD (BP5, BMD3)	651	86,5	5,1	0,0	8,4	87,7	3978
OECD (BMD3)	651	86,0	5,4	3,0	5,5	6,1	1335
Eurostat (BMD3)	6	0,0	0,2	0,0	99,8	71,3	10946
IMF CSID (BP6)	1228	70,6	16	3,0	10,3	323,8	1544
OECD (BMD4)	977	85,3	10,7	0,6	3,3	137,4	1543
Eurostat (BMD4)	98	1,1	59,9	0,0	39,0	97,3	3213
ASEAN	434	96,7	2,3	0,0	1,0	14,3	1149

Notes: The UNCTAD, OECD (BMD3), and Eurostat (BMD3) databases are directly comparable for the period 2001-2009, using the IMF's BPM5 compiling standard. The databases IMF CSID, OECD (BMD4), Eurostat (BMD4) and ASEAN follow the IMF's BPM6 compiling standard, for the period 2010-2013. Only a few overlapping years are available.

mirroring algorithm in UIFS4 allowed to reduce their impact drastically. Remaining cases were added to the category "empty cells. The last column of Table 2 compares the mean value of reported annual (positive) bilateral inward FDI stocks. It reflects that UIFS4 better captures the often smaller bilateral FDI transactions, like between 'South-South' countries, like e.g. the ASEAN FDI data.

Table 2 shows shows the results for the entire period 2001-2022. However, the overall data availability has much improved in the second half of this period, as is shown in Figure 3. Since 2021, more than 60% of all data cells was numerically filled. Probably, most of the missing values after 2010 are in fact zeros, but it just has not been possible to verify this, so we leave them as missings.[45] In fact, Figure 3 shows that a large part of statistical progress resulted from identifying empty data cells as being zeros. The quantity of FDI statistics –as measured by the number of filled bilateral data cells– apparently has improved over time.

Figure 3 UIFS4 database: Development of annual composition, 2001-2022

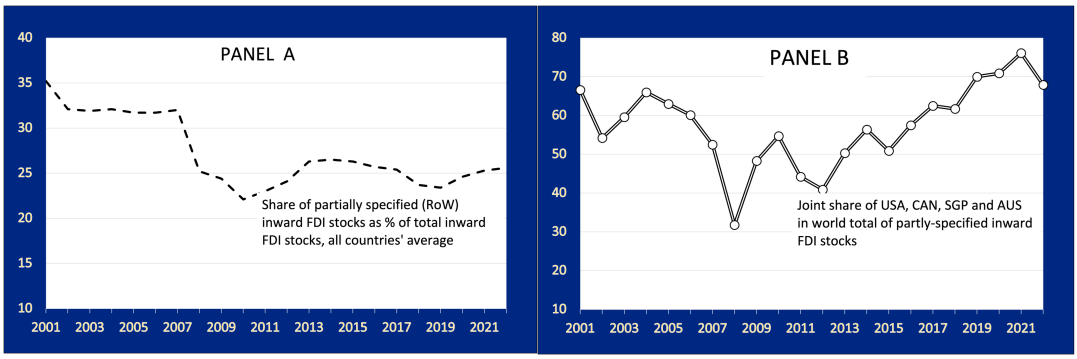


Till here, we have only discussed the results in terms of fully-bilateral specified FDI stocks. In equation (15), this corresponds with all data cells except the last row and the last column. These border vectors hold all FDI that is not fully specified, as a residual *rest-of-the_world* (RoW) category. From a research perpective, one would prefer to keep this category as small as possible, to make sure that the bilateral country patterns can be exhaustively explored. The RoW category is an unwanted obstacle. It is a smokescreen behind which countries can easily hide bilateral traffic that they do not want to expose to the public eye, like confidential or strategic bilateral traffic, or FDI that forms part of tax routing schemes. One of the aims of the UIFS4 mirroring operation was to reduce the size of this residual category. Figure 4 shows two salient results on partially-specified inward FDI. Panel A displays the development over time of the mean *rest-of-the-world* share for all countries. It dropped systematically between 2001 and 2010, from 35 to 22 percent, partly due to the publication of better source data. After the introduction of the BPM6 guidelines in 2009 the RoW category increased to 25 percent, where it remains more or less stable. Panel B tells a different story. It depicts the role of worldwide concentration of partly-specified inward FDI stocks. The four countries that contributed

[45] Consider, for example, the probability of bilateral FDI traffic between remote island states like Pitcairn Island, Monserrat, Falkland Islands, Guam, Faroer Islands, and Nauru. Note that in the panel structure of the data, each of these small economies has annually 231 potential partner countries. This explains the large share of missings.

most to the world's total reported RoW traffic are the USA, Canada, Singapore and Australia. Their joint world share dropped sharply from 70% in 2001 to around 30% in 2008. But from 2012 onwards the combined world share of these four countries jumped again to 76% of the world total. By implication, the good news is that the 128 other jurisdictions in UIFS4 together only contributed only 24% to the world's inward RoW traffic.

Figure 4 Partially specified (RoW) inward FDI stocks: Panel A - all countries, Panel B - Concentration at world level (4 top countries)



Note: Panel B shows the joint share of the USA, Canada, Singapore and Australia in the annual world total of partially-specified inward FDI stocks in UIFS4.

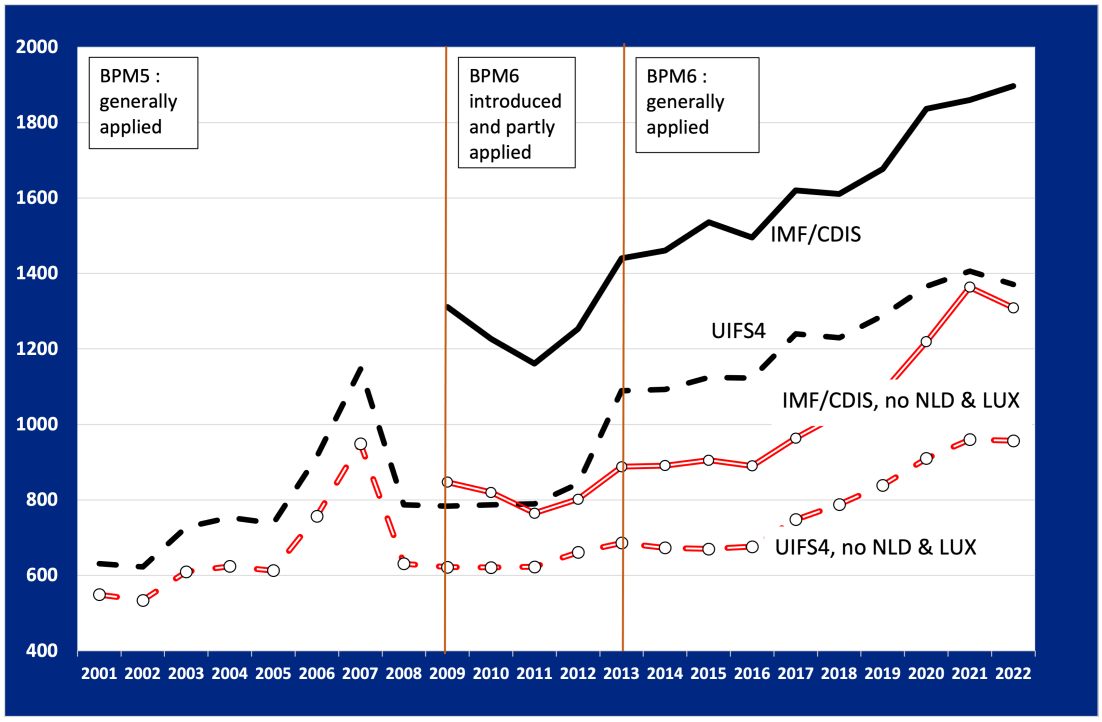
The introduction of the BPM6 balance-of-payments standards gave rise to a shockwise expansion of "phantom FDI".[46] We investigate how this affects the UIFS4 database. Figure 5 shows the annual pattern of mean bilateral inward FDI stocks, with the clear impacts of the 2008-2009 financial crisis and the introduction of BPM6. The graph compares the IMF/CDIS database and UIFS4. IMF/CDIS starts its data series upon the introduction of BPM6. Figure 5 shows that the IMF's mean annual value is about 40% higher than UIFS4 before 2013. The UIFS4 mirroring algorithm systematically gives a lower priority to data that are reported by the major offshore finance centres (like Netherlands, Luxembourg and Switzerland).[47] We did a small experiment to test whether our strategy has been succesfull.

We recalculated the worldwide mean bilateral inward FDI stocks, but now without Netherlands and Luxembourg. Both countries have a worldwide GDP share of about 7-8 percent. One would expect that this exclusion would only have effects of about the same order or even less.[48] The exclusion of Netherlands and Luxembourg led between 2009 and 2012 to a drop in mean inward FDI values of no less than 21% for UIFS4 and even 34% for IMF/CDIS. These results are indicated by the red lines with round markers in Figure 5. The fact that the impact for UIFS4 was 13% less than for IMF/CDIS might be regarded as a small succes for our mirroring algorithm.

[46] It is an inflation of outward and inward FDI that stems from over-reporting cause (a) in our Figure 1, earlier in this paper.
[47] Cf. Damgaard *et al*. (2019); Beck *et al*. (2023) and Alstadsæter *et al.* (2024).
[48] Casella *et al*. (2023) and Damgaard *et al*. (2024) found a linear connection between GDP size and the size of FDI stocks.

After 2012 *all FDI source data* are produced under BPM6 guidelines. It means that in this period there are longer BPM6-independent bilateral FDI data that the algorithm may select. This undermines the selection process. The results may be seen in Figure 5: the exclusion of only The Netherlands and Luxembourg means that the average inward bilateral FDI drops with about 40 percent between 2013 and 2017, both in UIFS4 and in the IMF/CDIS database. If deleting two small countries from calculating a worldwide average can have such a large effect, there must be a serious quality problem with the available FDI statistics. The conclusion can only be that we have not been able to fully

Figure 5 Time profiles of mean bilateral (inward) FDI stocks: UIFS4 and IMF/CDIS, 2001-2022

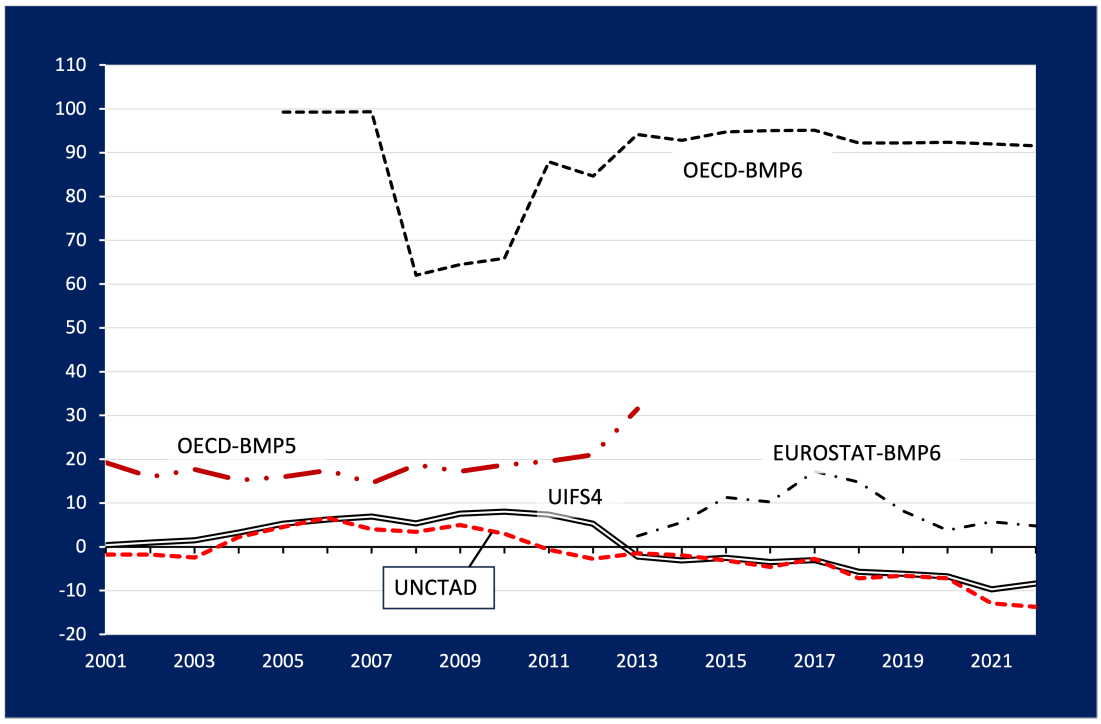


repair the BPM6 distortion in the present version of UIFS4. We decided to leave the UIFS4 database as it is: only based on reported FDI data. Nonetheless, our exclusion experiment illustrates that the distortion is very local (i.e. mostly concentrated in a limited number of reporting countries). Elsewhere, we investigate the possibilities of a heuristic correction strategy that recalculates the FDI traffic of these countries in order to achieve a more than proportional improvement for the overall quality of international bilateral FDI statistics (Kox, 2024b).

As last element for the evaluation of the UIFS4 results, we investigate the orthogonality of the world investment matrix, i.e. the balance between total inward FDI stocks and total outward FDI stocks at world level. At this aggregate level, some statistical discrepancies will always remain, if only due to limited to reporting threshold and limited statistical capabilities in some countries. In Section 3, the aggregate balance conditions are represented by equations (15,16). The variable Z_{wt} represents the aggregate (non-explained) unbalance between total inward and total outward FDI stocks. One of the impacts of BPM6 is that the symmetry between outward and inward

FDI is sacrificed; it is no longer imposed. A prime aim of the BPM6 operation was that FDI-related foreign liabilities would be charted more precisely. It went along with a relative attention shift to a full measurement of inward FDI and its financing structure. The consequence was that the reported aggregate FDI gap at world level became larger. Especially inward FDI stocks became over-reported. Foreign intra-company loans between fellow enterprises within a multinational firm became registered as inward FDI, even when there was no change in equity-related management control. The asset-focussed reading of source data in the UIFS4 algorithm should generate lower gaps at world level. In Figure 6 we compare the performance of UIFS4 against its main source files.[49] The figures for OECD, Eurostat and UNCTAD are strictly based on reported bilateral data.

Figure 6 Aggregate gap between total world FDI outstocks and FDI instocks (as % of world total FDI outstocks): UIFS4 and its source data



The annual gap for UIFS4 remains in the ±10% error margin, which is not the case for OECD and Eurostat data. The UIFS4 performance is largely compatible with the UNCTAD database of national aggregates, except for the early years of the BPM6 introduction. This convergence is remarkable. In the UNCTAD database, the national aggregate FDI stocks of SPE jurisdictions are estimated instead of based on reported bilateral data as in UIFS4 (cf. Section 4). We therefore regard this result as a proof for the soundness of our method

[49] This could not be done for the IMF CDIS database, because it is only published for inward FDI stocks. We found that the IMF *Coordinated Direct Investment Survey* (CDIS) dataset of bilateral FDI has also been constructed under this condition of mirror symmetry. While IMF gives only inward FDI data, we tried whether applying mirror symmetry by converting their annual data matrix would yield additional information on bilateral FDI traffic. This was not the case, and the IMF CDIS database therefore could not be used for comparison in Figure 6.

that is based on a selective, asset-centered reading of reported bilateral FDI stock data.[50] The degree of over-reporting in OECD and Eurostat FDI stock data should worry all users of these data. Though IMF CDIS does not report outward FDI stocks, we would expect a comparable degree of over-reporting if it did.

We trace down the origin of these massive amounts of non-attributable FDI stocks using the formal framework of Section 3, in particular the equations (17-20). Equation (19) yields $dnatsh_{it}^{outw}$, i.e. the share of non-attributables in a country's reported outward FDI stocks. Equation (20) gives $cwshar_{it}^{outw}$, which is a country's share in the annual world total of non-attributable outward FDI stocks. We apply both to the full UIFS4 database. As independent benchmark data (B_{it}^{EXT} and A_{it}^{EXT}), we use two different external datasets. The first one is the UNCTAD database on annual country totals for inward and outward FDI stocks, as reported in UNCTAD's annual flagship report *World Investment Report* (e.g. UNCTAD, 2023).[51] The other benchmark comes from 2023 update of the *External Wealth of Nations* database (cf. Lane and Milesi-Feretti, 2011; 2018). The EWN database collects data from the international investment position (FDI, portfolio investment, 'other investment') of all countries. The UNCTAD data will be used as the prime source, while the EWN data for national FDI positions are used as complement. In the case of conflicting values we use the smallest of both values; in most cases the UNCTAD values turned out to be smaller.

Figure 7 compares two periods around the systemic change in the FDI definition. We avoid the 2008-2010 period when the international financial crisis was in its acute phase. Instead, we compare the BPM5 period (2005-2007) and the BPM6 introduction (2012-2014). Figure 7 depicts $cwshar_{it}^{outw}$ on the Y-axis and log($dnatsh_{it}^{outw}$) on the X-axis. A hollow circle indicates a country's score under BPM5, a red square the BPM6 period.

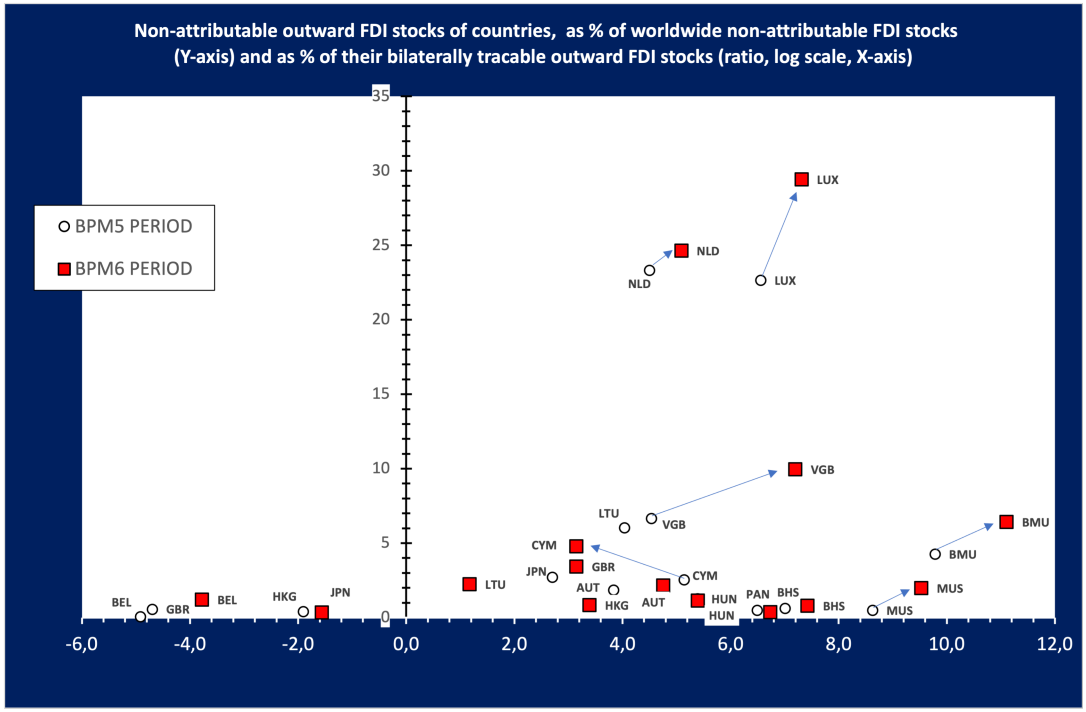
Most countries score very low on both criteria. Four countries (LUX, NLD, VGB and BMU) account for more than 70 percent of the world's non-attributable outward FDI stocks in the UIFS4 database. This finding explains the earlier experimental results in Figure 5. Three jurisdictions that are known to be financial turning tables have vastly increased their share in the world's non-attributable outward FDI stocks under BPM6: British Virgin Islands (VGB), Bermuda (BMU) and Mauritius (MUS).[52] We see this in a 'North-East'-ward or 'East'-ward shift in Figure 7. Because the X-axis of Figure 7 has a logarithmic scale, an 'East'-ward shift of 1 point represents a 10-fold increase. Hongkong (HKG), Austria (AUT) and Great Britain (GBR) have relatively low shares in the world's non-attributable outward FDI stocks. However, their strong "East"-ward shift on the X-axis reveals that the share of non-attributable stocks in their total outward FDI stocks increased sharply after the BPM6 introduction. Figure 7 allows to conclude that the introduction of BPM6 caused a significant increase in phantom FDI. The largest effects are concentrated in a small sample of 10-12 jurisdictions.

[50] Based on the Figure 5 experiment (exclusion of Netherlands and Luxembourg) we must, however, conclude that the post-BPM6 reported FDI stock statistics still hold extreme anomalies.

[51] Cf. the UNCTAD website (www.unctad.org/fdistatistics).

[52] Many of their FDI stock holdings are related to the USA (Milesi-Ferretti, 2024).

Figure 7 Impact of the BPM6 introduction on reported non-attributable outward FDI stocks, period 2005-7 versus period 2012-14



Legend country codes: AUT- Austria; BEL - Belgium; BHS - The Bahamas; BMU - Bermuda; CYM - Cayman Islands; GBR - Great Britain; HKG - Hong Kong; HUN - Hungary; JPN - Japan; LTU - Lithuania; LUX - Luxembourg; MUS - Mauritius; NLD - Netherlands; PAN - Panama; VGB - British Virgin Islands.

6. Conclusions

The paper has shown the feasibility of reconstructing a time-consistent data panel of bilateral FDI stocks. This time series builds on IMF's BPM5 definition of foreign direct investment as a measure of hierarchical management control of companies in other countries. Our UIFS4 database is a proof of concept. It works and performs comparatively well. However, the construction of FDI statistics is a job in which lots of experts and administrative people in all countries are and must be involved. These people now have to work within the framework of the *Balance of payments and international investment position manual, Sixth edition* (BPM6) and they deserve better. The paper has argued and shown that the BPM6 framework for FDI is deficient by introducing an ambiguous double standard for the definition of FDI. We sum up the main consequences:

- it is the cause of massive double counting and over-reporting of FDI stocks;
- it caused the situation that two partner countries can both record the same transaction as outward FDI;
- it confuses equity-based cross-border corporate control with financing decisions;
- it caused the loss of mirror symmetry between inward and outward FDI stocks as a valid statistical consistency check;

- it has caused frequent reports of negative FDI stocks, which only reflects financing-based decisions, often in the context of tax avoidance constructions (what is negative hierarchical management control of companies in other countries?);
- and last but not least, FDI statistics have lost their unique selling point as a consistent quantifier of hierarchical management-control relations between firms in different countries.

The BPM6 definition change for FDI in 2008/9 was a decision that was *only* guided by panic for a financial collapse in many OECD countries, and anxiety about the lack of information on intra-company financial liabilities in other countries. It is time to reconsider the wisdom of this decision of 15 years ago. The urgency of that moment is no longer effective and there are now other ways of getting information on intra-company financial liabilities in other countries. So, why not restore the unambiguous BPM5 definiton of FDI, and solve the liability information issue in another way. Under BPM6, the distinction between FDI and the other main items of the BoP's capital account (portfolio investment and 'other investment') has become blurred, which leads to unnecessary classification errors. So, also from this perspective, it seems time to change tack. However, the signs are not promising for the preparations of BPM7 that will be introduced in 2025 (e.g. Ohtsuka *et al*., 2022). Another 15 years of bad FDI statistics?

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