Repairing a historical mistake in bilateral FDI statistics: A new dataset covering 2001-2022

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

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Introduction

Foreign direct investment (FDI) statistics form a major 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 multi-annual transactions with other countries. Statistics on FDI are widely available and over a considerable period, often on a country-by-country basis. 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. National FDI data are compiled by central banks or national statistical offices, which may have different accounting practices. Two partner countries may thus report different values for their bilateral FDI traffic. Some countries suppress some bilateral FDI data for (national) confidentiality reasons. Other data are simply missing. Time series display sharp jumps after 2009 that are difficult to explain.[1] One finds negative bilateral investment, which may

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

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, probably related to the use of tax-avoiding constructions.[3] At the level of world aggregates, one finds large gaps between totals for inward and outward FDI. Statistical discrepancies could perhaps account for a few percents of differences, but one finds double-digit gaps. These issues raise valid questions about the quality and consistency of international FDI statistics. Among researchers there is growing concern about the informative content and effectiveness of current foreign direct investment statistics. Several authors argue that FDI data form a bad proxy for the activities of multinational companies and for the size of business investment in other countries.[4]

This paper addresses several of the problems. We present a new formal framework for quantifying FDI data quality. Our prime focus is on arriving at FDI data that are consistent over time, i.e. statistics that measure the same things in all years. As will be argued, this is no longer the case in official sources of FDI data. This paper proposes a feasible methodology to achieve time consistency, which will be shown in a full-blown proof of concept.

In a more orderly way, we will now sketch five new contributions which this paper brings 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, because it happened in the heat of the 2008-2010 financial crisis. In most OECD countries, monetary authorities feared for a possible financial break-down, leading to the nationalisation of several banks. A major concern was that multinational, non-financial firms might have accumulated liabilities and risk exposures due to offshore lending activities in weakly regulated and supervised jurisdictions. Such financial skeletons-in-the cupboard could turn into further unwelcome surprises. However, there was an acute lack of information on such offshore activities. As a shortcut, the Financial Stability Board, IMF and OECD together decided at the end of 2008 that intra-company cross-border loan activities of subsidiaries within multinational companies should from then onwards be considered as direct investment, so that they would be reported. However, this shortcut came at a big cost. It effectively implied a change in the official definition of FDI. Our paper will show that this step created a major consistency break in FDI time series that went along with 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 the loss of the unique selling point of FDI as the major quantifier of 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 FDI mirror statistics in combination with a

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

[3] Cf. Hansen *et a*l., 2024; 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; Angulo and Hierro, 2017; Blanchard and Alcalin, 2016; Wacker, 2013; Lipsey, 2010; Beugelsdijk *et al*, 2010.

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

multi-criterion selection algorithm. The framework yields quantitative indicators for analysing the quality of the FDI data. The mirroring procedure that we use, goes beyond FDI statistics. It may as well be used for other bilateral data (e.g. trade, finance).

The third contribution is the Unified Inward FDI Stocks (UIFS4) database of bilateral FDI stocks. It 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 a rules-based algorithm for the selection of data in the case that multiple sources are available. The rules include include indicators for the statistical capabilities of both partner countries, their role in tax-avoidance chains, whether they have a status as offshore finance hubs, and the type of FDI definition under which the data were compiled. The UIFS4 database is strictly based on reported bilateral data (IMF, OECD, UNCTAD, Eurostat, ASEAN and some minor sources). It uses no estimations or imputations to fill individual data cells. The database applies a strict separation between zeros and missing. The dataset might become an asset for research on economic globalisation and international economic relations.[6]

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

Finally, the paper quantifies the magnitude and the country structure of FDI over-reporting over a period of 22 years, which is longer than other available studies (Damgaard et al., 2024; Borga and Caliandro, 2018), which pay no specific attention to the impact of FDI definition change.

The structure of the rest of the paper is as follows. Section 1 describes the change in FDI definition that was introduced by OECD and IMF in 2009. It then argues why this discontinuity in FDI statistics should be considered as a historical mistake. Section 2 provides all 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 bilateral FDI dataset, include a data-selection algorithm. The formal framework also yields indicators for quantifying FDI over-reporting that will be used later in the paper. Section 4 sketches the original data sources for the UIFS4 dataset. Section 5 discusses the UIFS4 results by comparing these with the original source data. Section 6 quantifies the magnitude and structure of 'phantom FDI' that resulted from double counting. Section 7 summarises the overall conclusions and discusses the policy implications.

[6] The UIFS4 database will be made publicly available upon publication of the paper, including a replication package for the construction of the database. 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).

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 a foreign firm through the acquisition of a substantial share –at least 10%– of its voting stock (IMF 1993: 86).[7] Such investment may include the acquired equity stock, intra-company loans 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. The IMF labels international equity-related investment where the goal of management control is absent, as 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 in a different country?* Financing plays a secondary role for FDI; intra-company loans from the parent company form just one of the operational 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). It means that the control element prevails even if the multinational temporarily borrows from a subsidiary, because the parent controls the subsidiary's management.[9] Subsidiaries of multinationals also attract external financing from third parties, either locally or abroad. But this plays no role for the hierarchical control relation with the foreign parent company, even though locally attracted finance is

[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] 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 (e.g. Adarov and Stehrer, 2021; Martínez-Galán and Fontoura, 2019).

[9] In the case of a minority-owned subsidiary, a correction would be needed for the non-owned part of the subsidiary's equity (treating the corresponding loan as an arm's length finance transaction).

often considerably large.[10] Using more local financing may expand 'real' activities of the subsidiary, which would even extend the scope of the parent's control.

Things changed in the year 2008. It was the year of the largest financial crisis that OECD countries had experienced since the 1930s. 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). To prevent a full-scale financial breakdown, several large banks were nationalised. Unprecedented amounts of public money were used to shore up private banks and to keep credit lines open for the non-financial sector. Large financial companies, like AIG, Bear Stearns, Lehman Brothers, and Northern Rock went down.[11] Blanchard and Viñals (2009) wrote: "*Additionally, contingency plans should be devised to prepare for potential large-scale restructurings if circumstances deteriorate further*". It was in this atmosphere that the FDI definition change was introduced as part of a public urge to obtain more information on hidden liabilities, off-balance guarantees, and invisible asset write-downs of multinational firms.[12] Special attention of OECD and IMF went to intra-company banking hubs and special-purpose entities that facilitate capital transfers.[13] Both organisations agreed to achieve this *by changing the definition of FDI* and thus improve the measurement of incoming FDI. Intra-company loan provision between fellow companies in different countries should in the FDI statistics be considered as fully equivalent to the 'traditional' FDI (till then, only based on ownership and hierarchical management control). The change was codified in IMF's *Balance of payments and international investment position manual, sixth edition* (abbreviated as BPM6) that appeared in 2009. Here we read:

> *"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"* (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 weird tautology in the final sentence).

This definition and other changes in balance-of-payment statistics should be generally implemented from 2013 onwards.[14] Given the economic hectic of the financial crisis, it is not surprising that the, at first sight, unimportant FDI definition change has escaped the attention of most researchers and economists.

Before commenting on the definition change, we demonstrate exactly what happens under the new FDI definition and how it would have worked out under the old definition.

[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] Cf. Shaxson (2018).

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

[13] E.g. Working Group on International Investment Statistics, 2008; Sol, 2008); FSB Secretariat and IMF, 2009.

[14] Similar standards were almost simultaneously introduced by OECD (2008, their new FDI definition was labelled BMD4) and Eurostat.

For this purpose, we use an example of a multinational with headquarters in country A and three foreign subsidiaries, each in a different country (B, C, D). The multinational has a stacked ownership structure, which is not unusual.[15] The parent owns (FD1) subsidiary B, the latter majority-owns (FD2) subsidiary C that in its turn has ownership control (FD3) over intra-company finance hub D. So, there are two intermediary holdings, but the overall equity-based ownership structure is crisp clear; all subsidiaries are under full control of the parent company. For simplicity, we abstract from any local finance activities by firms B and C; they are only ownership pass-through subsidiaries. Country D is an "offshore" jurisdiction.[16] The subsidiary in D operates in international financial markets and organises finance for firms belonging to this parent company.[17] It provides a first loan to the parent company (L1) and a second loan (L2) to subsidiary B. We compare now what the loan activities of subsidiary D would do with FDI statistics, first under BPM5, then under BPM6. We assume perfect FDI statistics, where partner countries report the same bilateral FDI, one as outward FDI stock, the other as inward FDI stocks.

Under BPM5, this case would look simple. Firstly, all ownership relations (equity-based) between the parent and the subsidiaries remain unaltered. Subsidiary D still has no outward FDI at all. Secondly, the net intra-company loan component of outward FDI from the parent to subsidiary D changes, so that net outward FDI would become: (FD1–L1). Thirdly, if the parent has accepted to give a loan repayment guarantee to the outside lenders from which subsidiary D has attracted its finance, the parent would be wise to also add a repayment provision in its own financial accounts of about the same amount. This would again make net outward FDI equal to: FD1. So, in the end the intra-company loan activity will have little impact on FDI. However, there may be several reasons why firms do not take this third step. So, it is safe to assume net outward FDI being equal to (FD1–L1). A similar reasoning applies regarding the loan traffic between subsidiary B and subsidiary D.

Under BPM6, things change a lot because each intra-company loan that subsidiary D provides, will now be regarded as outward FDI originating from country D. So, country D suddenly has outward FDI to the amount of (L1+L2). In the FDI summary statistics, it is not visible that 100% of this amount is only formed by loans, while no assets (equity, ownership titles) are involved. At the same time, the pre-existing equity-based outward FDI amounts (FD1, FD2, FD3) remain intact and continue to be reflected in FDI statistics.

The remainder of this section will discuss the ramifications of the decision to change the FDI definition. Our simple example suffices to demonstrate that this practice must lead to double-counting and, at world level, to FDI inflation and 'phantom FDI'. This type of double counting is not at all rare. It forms a dominant case for intra-company financing hubs, within-company treasuries and regional sub-holdings in offshore finance centres.[18]

[15] Bolwijn *et al.* (2018) estimate that 30-40% of total FDI stock is routed through investment hubs

[16] "Offshore" means that such jurisdictions (e.g. Luxembourg, Cayman Islands, or British Virgin Islands) have in common that their finance markets are more laxly regulated and leniently supervised compared to the multinational's home country; their authorities tend to turn a blind eye to tax-evading constructions.

[17] Subsidiaries like D often can only attract foreign loans if the parent company provides separate guarantees that often do not show up in the annual report of the parent, partly because of the stacked ownership structure. Such off-balance (and therefore invisible) financial liabilities were exactly what the G20 and OECD countries were afraid of during the financial crisis.

[18] Cf. Zoromé (2007); Claassen and Van der Dool (2013); Pogliani *et al*. (2022).

The BPM6 text that was quoted earlier in this section states that buying foreign knowledge assets or taking a foreign loan are the equivalent of buying (a substantial share of) a foreign firm. Such contentions are at odds with received management theory and with normal business practice. The decision to locate a particular investment in a foreign country *precedes* the financing decision. Financing is of a more subordinate decision order, because financing normally may be attracted from several sources, which are completely exchangeable (fungible).[19] Conversely, the decision to acquire a controlling influence in existing foreign production capacity or the decision to set up new real investments in another country is *not* fungible at all. It forms a risk-taking, strategic development step. Therefore, when IMF (2009a:101) states "*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"*, it completely misses the essential difference between ownership and fungible business transactions.

Until 2009, the FDI concept had a single organizing principle (ownership-based hierarchical control), while BPM6 introduced ambiguity by introducing a double standard (ownership-based hierarchical control *'or'* providing cross-border loans). Hence, IMF statements 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 the same as selling voting stock that allows ownership-based hierarchical management control.

By breaking the exclusive link between FDI and ownership-based control under BPM6, a user of FDI statistics can no longer know what is being measured, which is a very serious quality deficiency. It makes FDI statistics unfit for research in international economics and for testing scientific hypotheses. Under BPM5, FDI statistics could be accepted as one of only a few plausible and generally available quantifiers of multinational firm activity.[20] The FDI time series now have lost their unique selling point as quantifier of hierarchical management control across borders.

The issue of FDI double-counting under BPM6 deserves a bit more attention. Using Ockham's razor, the 4-country example assumed perfect bilateral FDI statistics. However, FDI statistics are complex to compile, and countries are not equally good in this job. If only for that reason, the reported inward and outward FDI traffic between two partner countries will seldom fully match. So, in the presence of multinationals with stacked ownership structures, a second source of FDI double counting may exist.[21] Figure 1 maps

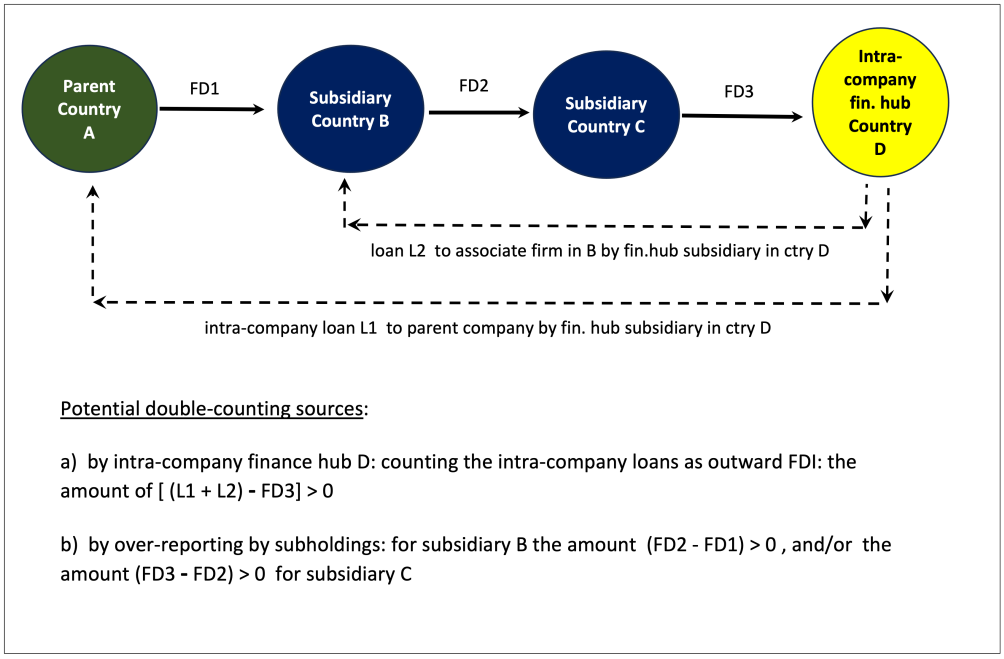
[19] The same fungibility holds for the decision to acquire foreign knowledge, either by obtaining a franchise, licensing a foreign patent, or hiring the services of a foreign knowledge-intensive services firm. The knowledge theory of the multinational enterprise assumes that firm ownership precedes a parent firm's decision to make its technology available to a foreign subsidiary. E.g. in Markusen (2002), ownership-based FDI is a precondition before making available proprietary knowledge assets (management, technology, marketing) and financial resources.

[20] Other sources are Eurostat's *Foreign Affiliate Trade Statistics* (FATS) and the US Bureau of Economic Analysis' *Activities 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.

[21] In the example of Figure1, this happens when sub-holding subsidiaries report the full value of their outward FDI stocks, but under-report the inward FDI stocks that they received from the ultimate parent company.

both potential sources of over-reporting of FDI. Channel *a)* is linked to the position of intra-company finance hubs (under BPM6), while channel *b)* is linked to use of stacked ownership structures, independent of BPM6.

Figure 1 Potential sources of FDI double counting



Anxiety for the financial stability of OECD countries, formed the basis for the introduction of BPM6. Nonetheless, both within IMF's Balance of Payments Committee (BOPCOM) and within OECD, its introduction was preceded by serious discussion. Literally on the same day that Lehman Brothers went broke, the BOPCOM had a regular meeting on the FDI definition change. The participants voiced several concerns on the proposals. There was opposition from, *inter alia*, the European Central Bank and the Dutch central bank. They predicted a surge of negative values in bilateral FDI statistics. Because there is no intuitive explanation for negative FDI stocks, this would make it more difficult to interpret FDI statistics.[22] Others remarked that the BPM6 definition change could mean that FDI data could no longer be used as yardstick for the relative investment attractiveness of countries (Sola, 2008) or that the compatibility between FDI data with domestic investment expenditures by non-multinational firms would become problematic (Claassen and Van der Dool, 2013:16-18). The new FDI definition would further mean the loss of a consistency check on the quality of bilateral FDI statistics, namely the use of mirror symmetry between the inward and outward FDI statistics of any country pair.[23] A further

[22] Cf. IMF (2008).

[23] "*In the BMD3* [OECD equivalent of as BPM5], *every inward transaction in one country was related to an outward transaction in the counterpart country. In BMD4 [OECD equivalent of as BPM6] 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).

critique was that the error percentage of bilateral FDI statistics would probably increase, between country groups (e.g. offshore financial centres versus other countries).[24]

With the benefit of hindsight, we may say that all these predictions were correct, but they were overruled in the 2008 crisis atmosphere. Our conclusion is that IMF/ OECD have deliberately introduced a system break in FDI statistics. All taken together, the BPM6 guidelines may have brought more insight in intra-company financial liabilities, but at the high price of low-quality, ambiguous FDI statistics. The equation of finance decisions with ownership decisions is not supported by management theory, nor by actual business practice. It remains unclear what is measured in current FDI statistics. The key statistical hurdles are non-compatibility of pre- and post-BPM6 statistics, double counting, loss of bilateral mirror symmetry, and over-reporting of bilateral flows.

2. … and how to repair it

The good news about the BPM6 FDI statistics is that they mostly offer more detailed statistics than those that were compiled under BPM5 guidelines. The data often inform about the composition the annual FDI traffic of a particular country pair. It allows to unravel 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). Bilateral FDI are often reported independently by each partner country, as outward or as inward FDI. So, this gives two independent potential data sources. Moreover, several international organisations publish their own sets of bilateral FDI data (IMF, OECD, Eurostat, ASEAN, UNCTAD until 2012). This paper develops a rule-based selection algorithm to proxy the FDI definition of BPM5. Before describing the process, it is useful to give the basic assumptions that underlie the reconstruction that we propose.

FDI transactions pass through several measuring points (central banks, national statistical organizations, government authorities) that potentially generate information on the FDI transaction. It may happen that one of two partner countries reports the value of the bilateral transaction, whereas the other country reports nothing, or reports that the FDI value is suppressed for confidentiality reasons.[25] In such cases, the reported data of partner countries become an alternative source of information. Under BPM5, the bilateral FDI is mirror symmetric: outward FDI of one partner should be about equal to the associated inward FDI of the partner country. Using reported mirror data may thus allow to construct a more complete bilateral picture; it defies data confidentiality and often also under-specification in a "Rest of World" category.

[24] 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 complicate the task of national compilers, because equity ownership is no longer their sole guide. They must also look at financing dependencies. The BPM6 definition change asks national compilers –in the case of intra-company finance hubs (subsidiary D in Figure 1)– to *ignore any knowledge of equity-based asset control* by an ultimate parent company.

[25] 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. In the case of confidentiality, the reporting country usually adds the relevant bilateral FDI amount to a residual category ("Other countries", "Unspecified", "Rest of World").

Bilateral FDI stock data are more widely available than FDI flow data. Bilateral FDI stocks are less volatile and –when asset-based– also semi-positive. The bilateral FDI flows 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. We therefore prefer FDI stocks. Moreover, FDI stocks have a consistent theoretical interpretation,[26] which is absent for FDI flows. Once using bilateral FDI stocks, one may always calculate first differences (annual changes).

Verified zeros in bilateral FDI patterns are important information carriers. They signal the presence of impeding 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. Missing bilateral FDI data could mean that there was no bilateral FDI (zero), but we just don't know. In such cases, we respect the integrity of the original source data and refrain from substituting 'missings' by zeros.

Following Clausing (2016), we preferably use equity-based bilateral FDI data. In this way we avoid BPM6-specific quasi-FDI data that only measures the loan traffic of intra-company finance hubs, but also other forms of FDI that predominantly reflect financing constructions. This is not always possible, because not all bilateral FDI stocks are specified in terms of their composition (equity, reinvested profits and intra-company loan positions).

Negative FDI stocks were quite rare under BPM5, although it often occurred in FDI *flow* statistics.[27] Under BPM6, negative bilateral FDI is reported 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. Even negative equity components occur, although this has been hotly debated.[28] According to Borga (2019), the compilers of FDI statistics should deal with the principle that "*The equity value of an enterprise represents the value that remains for shareholders once all debts have been paid*". This statement reflects the banker's view of a firm. However, FDI statistics are not about the equity value of firms, but they quantify cross-border ownership-based control of management. It is notably hard to imagine a negative 'lasting influence in management'. The structure of debt-financed international investments is heavily impacted by fiscal motives and tax-routing decisions. Most national systems of corporate income tax have a bias that favours debt-based financing above equity-based financing (Keen and De Mooij, 2016). National systems of corporate income tend to allow tax deductibility of interests paid on loans, but not for a threshold return to equity capital. This asymmetry distorts corporate finance decisions: corporations prefer debt financing over equity financing beyond the level which they

[26] The knowledge-capital theory of FDI offers an asset-based theoretical framework (e.g. Markusen, 2002; Anderson et al., 2019; Kox and Rojas, 2020; Kox, 2024; Davies and Markusen, 2024).

[27] 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"*. A fourth reason may be due to changes in the annual valuation of the financing component or of real assets.

[28] 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.

would otherwise have chosen.[29] The intra-company loan activity reflects this biased 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.[30] 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 the case that alternative data are missing, we do not replace negative values by a zero, but by a 'missing'. The reason is that is that zero is a too powerful statement, while we do not have enough information to justify it.

Bilateral FDI is –in most countries– more likely to be under-reported rather than over-reported.[31] 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 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

[29] 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).

[30] Regarding FDI, Elkjaer and Anacki (2023) propose to set these negative values 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 others argued that many FDI companies do not have a limited-liability legal form. It remains to be seen what IMF's upcoming BMP7 standard will say about this issue (cf. IMF, 2024).

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

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 centre?*) we must know the ultimate origin country (UOC), which mostly is where the multinational's headquarter 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 perspective, 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.[32] What we really want to know is the real FDI stocks between the ultimate origin country (UOC) and the ultimate host country (UHC). The present available source statistics do not yet allow this. Most current FDI statistics report only about FDI traffic with the *immediate* partner country (IMC). Experimental OECD data (OECD, 2015c) demonstrate that the disturbing role of all 'intermediary countries' is very locally concentrated and mostly associated with offshore finance centres in a limited number of OECD countries.[33] By identifying and quantifying the role of FDI inflation by offshore finance centres most of the bias problem will be removed. 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[34]

The world FDI matrix describes equity-based FDI stock ownership relations for country pairs. Basically, it has a simple structure. Its construction follows the consistent FDI interpretation of IMF's BPM5 guidelines and the assumptions described in in the preceding section. 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. The world FDI matrix then has the following structure:

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

[32] The methodology of tax avoidance is reviewed in, *inter alia*, Dharmapala (2014), Clausing (2016), Dowd *et al*. (2017), Cobham and Janský (2020), 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).

[33] 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 good approximation of their real UOC-impact.

[34] Readers that prefer a more verbal description may skip this section. Sections 4 and 5 briefly explain the construction of the dataset, its source data and results.

On the diagonal [a_{11t} a_{22t} ... a_{nnt}] we find what firms invest in their own country; these data are measured in the domestic capital accumulation account, not in the balance of payments. 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 a 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 the direction-specific bilateral stocks (a_{n2}, a_{2n}) as separate; there is no 'netting' of both uni-directional stocks. We may now derive the world matrix $\boldsymbol{OW_t}$ of outward FDI stocks with data 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} ... a_{nnt}] now holds zeros. For brevity of notation, we have suppressed the time suffices within the matrix brackets. Similarly, we may formulate the world matrix $\boldsymbol{IW_t}$ of inward FDI stocks per reporting country:

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

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 a 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:

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

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:

- systematic errors, such as BPM6-based distortions (taking loans from a subsidiary 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-

transparency 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.

These imperfections reduce the correlation between the $\{a_{ijt}, b_{jit}\}$ data for bilateral FDI stocks per country pair. It is therefore 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 continuing with the construction of the Unified Inward FDI Stocks (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' may differ 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 specified, while v_{it} is the last country for which inward FDI is bilaterally specified. 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 equation (4). Instead, we are in a situation that we must 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 extend 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}, using reported and bilaterally specified data. The non-specified sub-aggregates (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 to reflect that they are proxies for the non-observed 'true' value. Each international organisation that publishes bilateral FDI statistics has its own statistical system integrity that must be guarded in the mirroring operation. We therefore add an additional suffix *q*. The approximation procedure starts with the statistics of data-publishing institution $q \in Q\{1,2,.,m\}$. Each organisation publishes its own a_{ijqt} or b_{ijqt} data elements. Formally we have:

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

in which the expression "$\triangleq^{\mathrm{m}} \mathbb{R}_+$: " 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-transparency status or the status of an offshore finance centre (OFC); (6) data reported by a country that has 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:

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

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-transparency 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.[35] 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:

$$\forall\, b_{ijt} \overset{m}{=} \mathbb{R}_{+}: \left(b_{ij1t}\,, b_{ij2t}\,, b_{ij3t}, \ldots, b_{ijmt}\right) \qquad (11)$$

These steps yield two relatively independent matrices (***IW**^B*, ***OW**^B*), now with suffix ***^B*** to distinguish them from the matrices described in equations (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 '*bi-proportional matrix balancing*' technique (Lahr and De Mesnard, 2004). Our application of this technique uses ***IW**^B*** and ***OW**^B*** iteratively and cyclically as source and as prediction. Mirror values per country pair ($a_{ijt} \leftrightarrow b_{jit}$; $a_{jit} \leftrightarrow b_{ijt}$) refer to the same FDI traffic. We already used these linked matrix elements as a mutual predictor (equation 9).

This will now be done on a more 'industrial' scale, namely matrix-by-matrix. as is depicted in Figure 2. The procedure is that one of the matrices ***IW**^B*** and ***OW**^B*** is taken as basis. Starting with ***IW**^B***, we transpose the matrix by switching rows and columns [***IW**^B***]$^{\mathrm{T}}$, so that each reporting country becomes a partner country, and partners become reporting countries. This new matrix 'predicts' ***OW**^B***. Then compare the actual ***OW**^B*** and the predicted matrix [***IW**^B***]$^{\mathrm{T}}$ 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 ***OW**^B***. This new matrix, labelled ***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. The starting matrix of each 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.

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 equations 5-8). The problem is now that the partially specified aggregates (ROW_i^{in}, ROW_i^{out}) of equations (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

[35] 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.

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

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 (details about these benchmark data will be given in Section 4). The approximation procedure of the partially specified annual FDI stocks ($XLG_{it}^{IN}, XLG_{it}^{OUT}$) is as follows:

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

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

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 right-hand side 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 $\boldsymbol{OW^F}$, step 11 in Figure 2). Note that equation (12) restricts XLG_{it}^{IN} to the real, semi-positive domain, i.e. XLG_{it}^{IN} may be zero, and the same holds in equation (13).

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 and inward FDI stocks (respectively $\boldsymbol{OW^{TOT}}$ and $\boldsymbol{IW^{TOT}}$), 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 equation (4). However, there is no reason that the mirror symmetry would also hold for the last row and the last column of both matrices. 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 each year. It is defined as:

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

This completes the formal description of constructing the UIFS4 database. The matrices are strictly built on reported data. There is no imputation or estimation for missing data.[36] 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.

A caveat must be mentioned here. Our approach diminishes the impact of the BPM6 distortions, but it cannot not fully eradicate them after 2013. The reason is that after this year there are no more real alternative data sources available for the BPM6-conform FDI data. This means that each element ($a_{ijt} \rightleftarrows b_{jit}$) may still hold the impact of the BPM6 distortions. Indirectly, via equation (16), most effects 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}).

Indicators of BPM6 distortions. We may use the formal framework to derive a few useful indicators of FDI over-reporting. Equations (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:

[36] This is an advantage of UIFS4 compared to the OECD AMNE database of bilateral FDI (cf. Cai *et al*., 2023), which makes extensive use of data imputation.

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

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

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. Equations (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-attributable FDI in reported FDI stocks. It can be calculated for outward and inward FDI stocks:

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

The $dnatsh_{it}$ ratios for countries with small domestic economies and no activities in the offshore finance or in the tax-sheltering and tax-avoidance business, are expected to be close to zero. However, for small economies with lots of activities in offshore finance or in the tax-sheltering we may expect ratios that are sky-high. All other countries will be somewhere in between.[37]

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*),[38] OECD (*OECD International Direct Investment Statistics*), Eurostat (*International Investment Position Statistics*) and UNCTAD (*World Investment Report*).[39] 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 few smaller sources (ASEAN,

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

[38] Cf. IMF (2015a, 2015b); Angulo and Hierro (2017).

[39] 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.

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 FDI compiling guidelines after 2009, 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.

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 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. Section 3) expands the number of data cells with semi-positive numerical information. Each of the four databases with original 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

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**

method. We therefore first apply, for each data source, the set of five decision rules for diverging mirror values per country pair.[40]

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 (EU countries), OECD, Eurostat (other countries).

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

As independent benchmark data[41], we use two different external datasets. UNCTAD's annual flagship report *World Investment Report* provides national totals for inward and outward FDI stocks.[42] The *External Wealth of Nations* (EWN) database gives the same data, but these are based on data from the capital account of national balance of payments (Lane and Milesi-Feretti, 2011; 2018), of which we use the 2023 update. The UNCTAD are used as the prime source, while the EWN data are used as a 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. This is not surprising, because the EWN uses nominal balance-of-payments data that are compiled under BPM6 guidelines.

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 Statistical Performance Indicator (Cameron *et al*. (2019) 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).

5. Results: comparing UIFS4 with its original source files

The Unified Inward FDI Stocks (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 none of the source files reported any numeric value. 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. Overall, the UIFS4 database contains 557,300 numerical values (46,7%). Figure 3 shows that over time the database became more complete. 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 left these cells empty.[43] 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.

[41] Used as benchmark for partially-specified national data (equations 12,13) and for the calculation of national over- and under-reporting (equations 17,18) in section 3.

[42] Cf. UNCTAD, 2023, and the UNCTAD website (www.unctad.org/fdistatistics). The UNCTAD dataset of aggregate national FDI stocks partly draws on national bilateral data. In the compiling stage, UNCTAD directly removes data from jurisdictions with a known reputation for hosting many tax-related special-purpose entities (SPEs). For these jurisdictions they estimate the real FDI stocks their implied investment method (Bolwijn et al. 2018; Casella et al., 2023; based on the relation with FDI stocks and GDP) and the IMF estimation method (Damgaard et al. 2024, 2019). In our reconstruction of BPM5-equivalent FDI stocks, we found we found many cases of semi-positive total inward and outward FDI stocks where UNCTAD reported zero FDI stocks; we have corrected the UNCTAD data in these cases. In most of the added cases, the FDI magnitude is small, with little effect on the cumulative pattern of global FDI.

[43] Consider, for example, the low probability of bilateral FDI traffic between remote island states like Pitcairn Island, Monserrat, Falkland Islands, Guam, Faroer Islands, and Nauru. In the bilateral panel structure of the data, these and other other tiny economies annually have 231 potential partner countries. This explains the large share of missings.

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

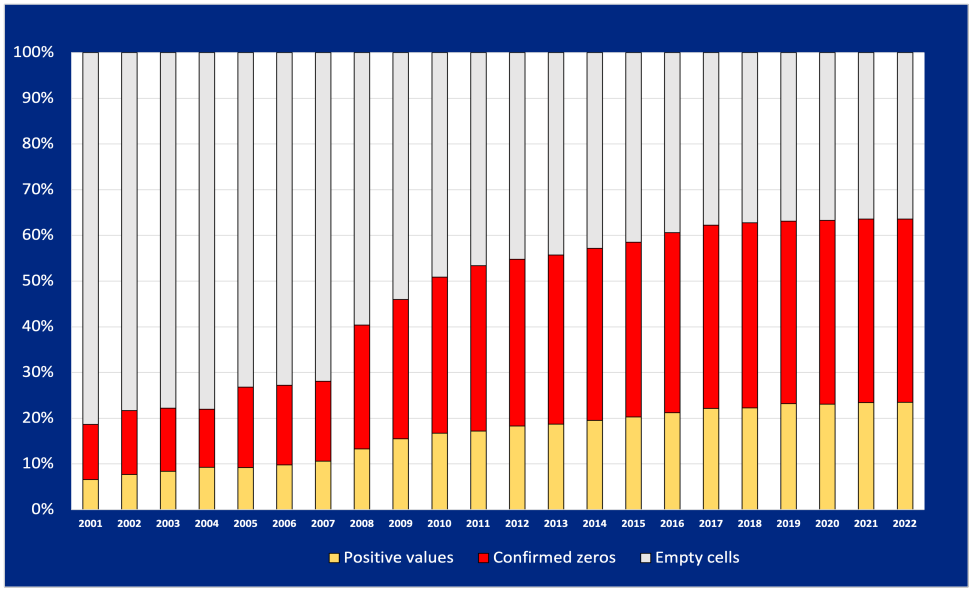


Table 2 compares the UIFS4 database with its source files that all cover only a limited part of the 2001-2022 period. The absolute number of numeric-filled data cells is higher than any of the source files. In relative terms, only the Eurostat (BMD4) performs better than UIFS4, particularly by reporting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

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

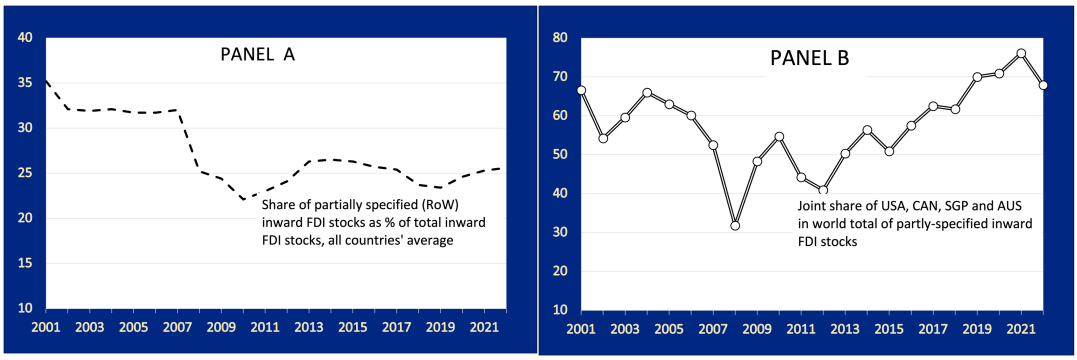
Notes: The UNCTAD, OECD (BMD3), and Eurostat (BMD3) databases are directly comparable for the period 2001-2009, using the IMF's BPM5 compiling standard. The databases IMF CSID, OECD (BMD4), Eurostat (BMD4) and ASEAN follow the IMF's BPM6 compiling standard, for the period 2010-2013. Only a few overlapping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

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 values were repressed for confidentiality reasons, the use of the 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.

So far, we discussed the results in terms of fully-bilateral specified FDI stocks.[44] Per country we add a residual *rest-of-the-world* (RoW) category. From a research perspective, one would prefer to keep this category as small as possible. The RoW category is an unwanted 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 the share of 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 stable. This is still an unwanted situation if it would apply to all countries. Therefore, we checked for the distribution of the world's RoW total. Panel B shows however that total worldwide RoW data are strongly

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.

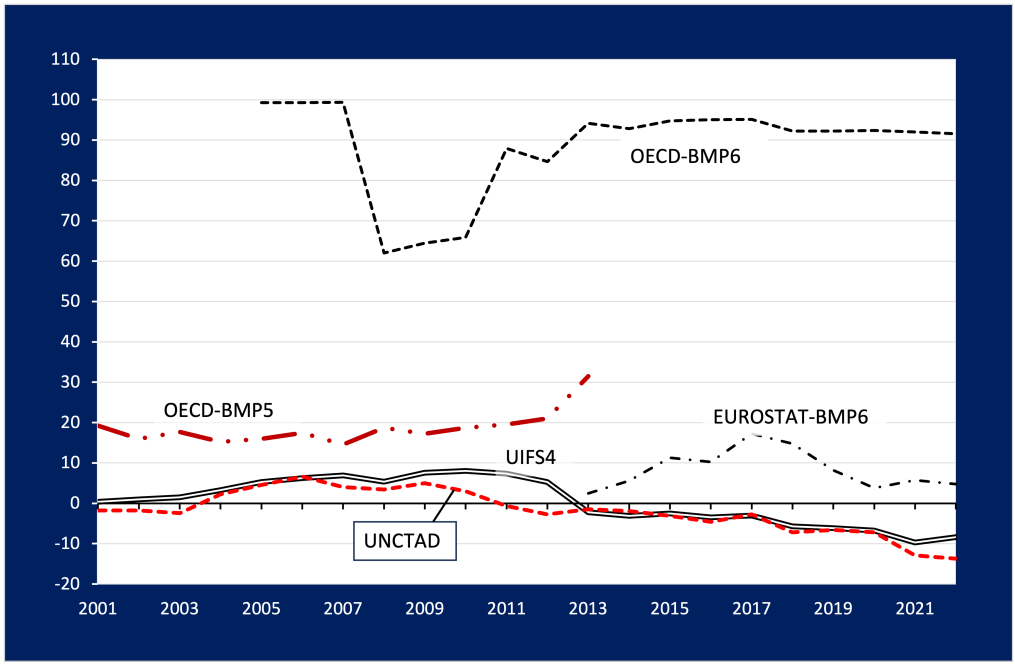
concentrated in just four countries: USA, Canada, Singapore and Australia. Their joint world share dropped sharply from 70% in 2001 to around 30% in 2008. After 2012, their combined world share jumped again to 76% of the world total. It means that the 228 other jurisdictions in the database together accounted for only 24% of the world's total partly-specified FDI stocks.

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

[44] In Section 3 (equation 15), it corresponds with all data cells except the last row and the last column.

outward FDI stocks at world level. At this aggregate level, some statistical discrepancies will always remain, if only due to limited to reporting thresholds and limited statistical capabilities in some countries.[45] With the introduction of BPM6, the former symmetry between outward and inward FDI evaporates after 2013. Especially inward FDI stocks became over-reported. The asset-focussed reading of source data in the UIFS4 algorithm should generate lower gaps at world level. In Figure 5 we compare the performance of UIFS4 against its main source files. The figures for OECD, Eurostat and UNCTAD are strictly based on reported bilateral 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

Figure 5 Aggregate gap between total world outward FDI stocks and inward FDI stocks (as % of world total outward FDI stocks): UIFS4 and its source data



early years of the BPM6 introduction. This convergence is remarkable. In the UNCTAD database, the national aggregate FDI stocks of tax havens and offshore finance centres are estimated instead of based on reported bilateral data as in UIFS4. We therefore regard this result as a proof for the soundness of our method that is based on a selective, asset-centred reading of reported bilateral FDI stock data. The degree of over-reporting in OECD and Eurostat FDI stock data should worry all users of these data. Figure 5 does not show the IMF data, because their CDIS database does not report outward FDI stocks.[46]

[45] In Section 3, the aggregate balance conditions are represented by equations (15,16). The variable Z_{wt} represents the aggregate (non-explained) disparity between total inward and total outward FDI stocks.

[46] The number of jurisdictions that report BPM6-type outward FDI stocks to IMF increased from 61 to 82 over the years, but IMF does not publish these data. Our informed guess is that publishing their outward FDI stock data would show the asymmetry between inward and outward FDI stocks, identical to the OECD and Eurostat data in Figure 5. We tried whether applying mirror symmetry (by converting their annual data matrix) would yield any additional information on bilateral FDI traffic. This was not the case, indicating that the CDIS dataset must have been constructed under assumed mirror symmetry, although that is incompatible with BPM6-type FDI data.

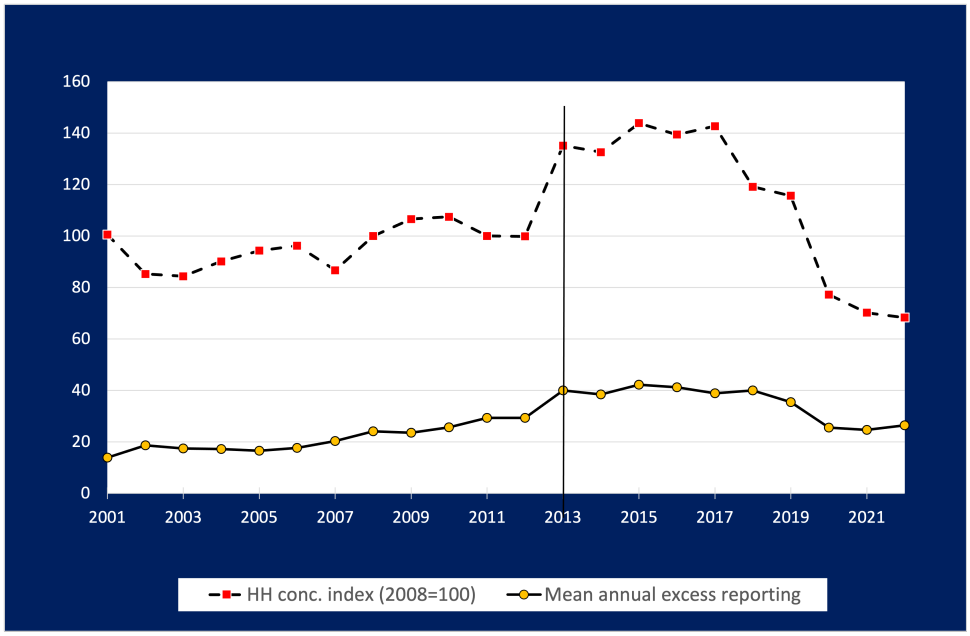
Overall, the conclusion of comparing UIFS4 with its original source files is that our approach largely succeeds in overcoming the systemic data break between the BPM5 period (2001-2011) and the BPM6 period (2012-2022).

6. Impacts of the BPM6 historical error

The introduction of the BPM6 balance-of-payments standards caused a shock-wise expansion of "phantom FDI", i.e. FDI stocks that cannot be traced via asset-based bilateral FDI data. This section shows the dimensions of the FDI over-reporting problem that is directly associated with the 2008 OECD/IMF decision to change the definition of FDI. Because our calculation framework emulates the FDI definition of BPM5, the UIFS4 data in this section can be considered as a counterfactual alternative.[47]

Figure 6 depicts for all countries the mean over-reporting share (%) in their total outward FDI stocks (based on eqn.17-18). The graph shows that before 2010 around 20% excess

Figure 6 Mean annual excess reporting as % of outward FDI stocks (all countries) and its distribution characteristics (Herfindahl-Hirschman concentration index), 2001-2022



reporting already occurred. Most probably, this was due to double-counting source *b)* in Figure 1. If a multinational firm uses stacked (sub-)holding constructions in several countries, it may easily happen that the same real firm assets are effectively reported twice or more by the different jurisdictions. However, the introduction of BPM6 invoked a jump in excess reporting to around 40% annually, with an anticipation effect that already started in 2010. Damgaard *et al.* (2024) find the same figure for 2017, although they use a different method. It is good to ask oneself for what other macro-economic data would we tolerate 40% over-reporting? After 2018, the mean over-reporting share

[47] All data in this section are derived from the formal accounting framework of Section 3, especially the equations (17-20), that allow to show the different dimensions of worldwide FDI over-reporting.

dropped again to the level of 2010.[48] Figure 6 also depicts the changes in the distribution that is behind the mean over-reporting score. For this goal, we calculated the Herfindahl-Hirschman (HH) concentration index of annual country shares in global over-reporting of outward FDI stocks.[49] The HH index shows that the BPM6 introduction of 2013 went along with steeply increased concentration of over-reported outward FDI stocks by a small number of countries. This should be no big surprise, because the BPM6 definition change opened the over-reporting channel *a)* of Figure 1. It deals with over-reporting by jurisdictions that are intra-company finance hubs (offshore finance centres, financial turning tables). There are not so many of these; they must have a financial sector that is developed enough to cater its services to non-resident firms (Zoromé, 2007; Pogliani *et al*., 2022). Hence, our testable prediction is that the over-reported, non-attributable FDI stocks must be concentrated in offshore finance centres. From 2017 onwards, the concentration index falls again, and faster than the mean over-reporting share in Figure 6. The reason for that is mainly that more jurisdictions discovered that being an offshore finance centre is a lucrative business.[50]

We return to the testable prediction. It is useful to distinguish two dimensions in the performance of individual countries:[51] (a) what share does non-attributable FDI have in its own outward FDI stocks, and (b) does it matter for the world's total non-attributable FDI, i.e. what share does the country have in the latter variable? Figure 7 portrays both aspects, comparing the role of the world's most important players. The vertical axis displays aspect (b), while the horizontal axis describes the performance for aspect (a).[52] The graph also includes a time dimension: period 2005-2007 (BPM5, hollow cycle), and the period 2012-2014 (BPM6, red square). 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. Most countries score very low on both criteria. Most important for the predicted increase in concentration of the over-reporting phenomenon is the direction of a country's performance shift. For the largest intra-company finance hubs, we should see a 'North-East' shift under BPM6. This appears to be correct, as indicated by the arrows. 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).[53] Hongkong (HKG), Austria (AUT)

[48] It would be interesting to investigate whether the abatement of tax avoidance constructions by G20 and OECD countries (more transparency, country-by-country reporting, peer screening of fiscal policies) played a role. This factor could contribute to more transparency on intermediary holding constructions.

[49] We used the normalised HH index, defined as: $HHI_t = \left[\sum_i^N XS_{it}^2 - \frac{1}{N}\right] / \left[1 - \frac{1}{N}\right]$, in which XS_{it}^2 is the square of each country's annual excess reporting, and N is the number of jurisdictions. If over-reporting would be equally distributed across countries, all would have a $1/N$ share. The HHI index measures how far the real distribution deviates from this counterfactual. The HHI values for the 2001-2022 period varied between 974 and 2052. Using an index of the HHI (2010=100) made it possible that Figure 6 simultaneously visualises the distribution characteristics with the development of the mean over-reporting rate.

[50] E.g. the entry of Mauritius, Estonia, Iceland, Belgium, British Channel Islands (Guernsey, Jersey) and Slovakia in this type of financial services.

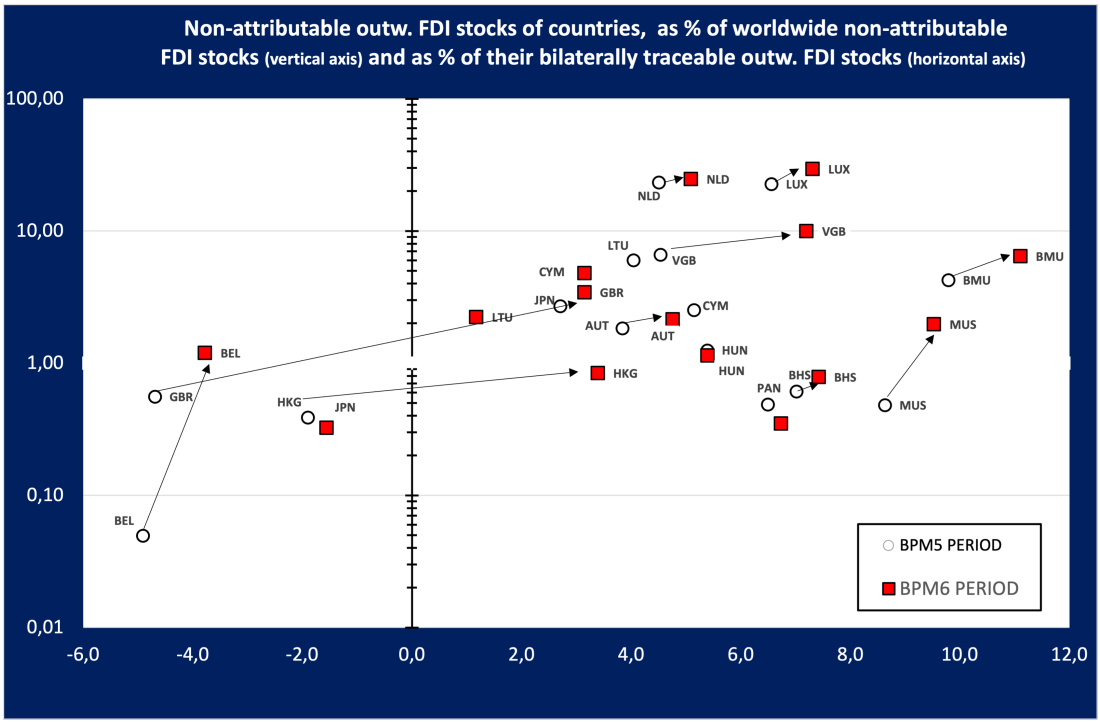
[51] Both dimensions are provided by, respectively, equations (19) and (20) in Section 3.

[52] Because of the huge disparities between the performance of individual countries, both axes have a logarithmic scale, based on powers of 10. A negative score on the horizontal axis indicates a country score between 0 and 1. An 'East'-ward shift on the horizontal axis of 1 point represents a 10-fold increase.

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

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, and moreover, that most effects are concentrated in a small sample of 10-12 jurisdictions.

Figure 7 Impact of the BPM6 introduction on reported non-attributable outward FDI stocks, period 2005-07 versus period 2012-14

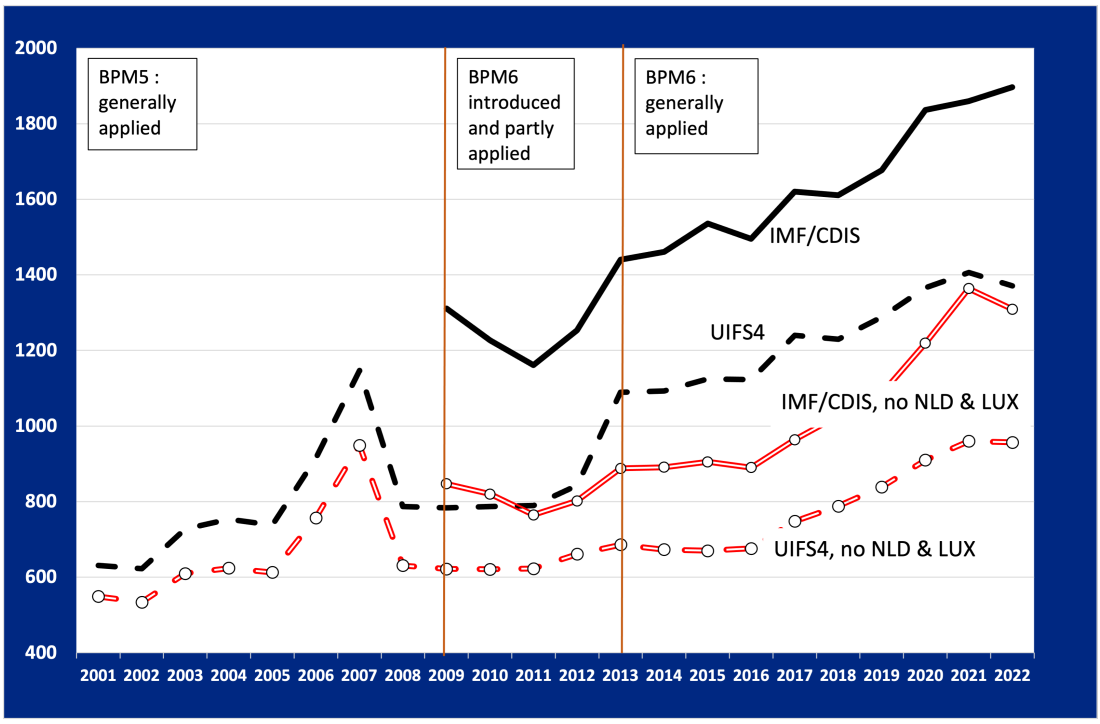


Dimensionality: both axes have a logarithmic scale (powers of 10). **Legend country codes**: AUT- Austria; BEL - Belgium; BHS - The Bahamas; BMU - Bermuda; CYM - Cayman Islands; GBR - Great Britain; HKG - Hong Kong; HUN - Hungary; JPN - Japan; LTU - Lithuania; LUX - Luxembourg; MUS - Mauritius; NLD - Netherlands; PAN - Panama; VGB - British Virgin Islands.

Finally, we return to the role of non-attributable FDI in the leading FDI statistics of IMF, its Coordinated Direct Investment Survey (CDIS). While BPM6 was officially introduced in 2013, the IMF has back-casted bilateral FDI data between 2009 and 2013, using the BPM6 methodology. This allows us to compare data of IMF/CDIS with its equivalent in the UIFS4 database over the period 2009-2022. Figure 8 shows the time profile of the mean annual value of inward FDI stock in both databases (both in current prices and exchange rates).

Between 2009 and 2013, the IMF's mean annual value of FDI stock is about 40% higher than the mean for UIFS4. This difference can only be attributed to double-counting and to intra-company loans that ––from the perspective of IMF's own BPM5 FDI definition–– are incorrectly labelled as direct investment. From 2013 onwards, all FDI source data are

Figure 8 Time profiles of mean bilateral (inward) FDI stocks: IMF/CDIS versus UIFS4, 2001-2022 (with and without Netherlands and Luxembourg)



produced under BPM6 guidelines and 'polluted' by it. For FDI stocks data, as a cumulative variable, the problems have become pervasive. Without alternative asset-based FDI data, the effectiveness of the UIFS4 data selection algorithm shrinks. Figure 8 shows that after 2013 both IMF/CDI and UIFS4 mean values are trending upwards; the upward trend for UIFS4 is only smaller. The preposterous proportions of FDI double-counting can be illustrated with a small experiment. Figure 7 already showed that much non-attributable FDI stocks are found in the data of Netherlands and Luxembourg.[54] So, Figure 8 also provides a time series of the mean inward FDI stocks for IMF/CDIS and UIFS4, but now with omitting the data of both countries. Both countries have a combined 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.[55] Now look at what happens with the world mean in Figure 8 (red lines with round markers). The exclusion of Netherlands and Luxembourg led between 2009 and 2013 to a 21% drop in mean FDI values for UIFS4 and even to a drop by 34% for IMF/CDIS data.[56] If omitting two small countries from calculating a worldwide average can have such a large effect, there must be a vast quality problem with the available FDI statistics that

[54] Beck *et al.* (2023) document the outsized role that The Netherlands and Luxembourg have due to their dual role as intra-company finance hubs, and as centre of securities issuance. See also Garcia-Bernardo *et al*., 2017; Damgaard *et al*., 2019; Alstadsæter *et al*., 2024.
[55] Casella *et al*. (2023) and Damgaard *et al*. (2024) found a linear connection between GDP size and FDI-stocks.
[56] The fact that the impact for UIFS4 was 13% less than for IMF/CDIS might be regarded as a small success for the UIFS4 mirroring algorithm.

calls for a serious reconsideration of earlier decisions. This is admitted in a recent paper for the IMF Balance of Payments Committee (but without proposals to remedy it).[57]

Our results show that official FDI data before and after 2013 are hardly compatible and can no longer be considered as a quantifying proxy for the magnitude and pattern of cross-border hierarchical management control. The least that can be done in econometric studies using FDI statistics is to control for the systemic measurement break. The simplest way to do so is probably to use a BPM6 dummy that is zero (0) before 2012 and one (1) in all years after 2011 (some countries already started to apply BPM6 guidelines before 2013). But even with a BPM6 dummy, FDI statistics have become ambiguous about what they are measuring: intra-company financing traffic or ownership-based control of foreign companies. Researchers should be careful with using current FDI data for testing hypotheses related to border-crossing management control.

7. Conclusions and policy implications

In a review article on current macro-economic research, Glandon et al. (2023) stress that feedback between theory and measurement is the main way forward for mature quantitative sciences. For FDI, this feedback link must be restored. The systemic break in FDI series is an historical mistake that is understandable from the circumstances of the Great Financial Crisis (2008-2010), but that almost 20 years later urgently calls for repair action. We have shown that the double-counting distortion in FDI statistics is massive and tends to increase in magnitude. Three factors have made the distortion pervasive. One is the central role of intra-company finance hubs whose loans to other subsidiaries of the same parent company have been labelled as FDI under the BPM6 balance of payment guidelines. The second factor is the cumulative character of FDI stocks; it creates a channel through which historical double-counting errors tend to be carried forward in time. And a third factor in the background is that most national tax systems create a permanent incentive to stimulate loan-financed investment above equity-based investment (cf. footnote 29).

The paper has demonstrated the feasibility of reconstructing a time-consistent data panel of bilateral FDI stocks, using the IMF/BPM5 asset-based definition of FDI, measuring the extent of border-crossing, ownership-based control of companies in other countries. The UIFS4 database and its accounting framework is therefore a proof of concept. 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. They now 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:

- The equation of financing decisions with equity-based cross-border corporate control does not converge with any management theory.
- BPM6 causes a massive increase in double counting and over-reported FDI stocks.

[57] "*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* [..]" (Kothe *et al.,* 2022: 2).

- It makes FDI statistics ambiguous: to what extent do they measure intra-company financing traffic, and to what extent does it quantify ownership-based control of foreign companies.
- FDI statistics have lost their unique selling point as a consistent quantifier of hierarchical management-control relations between firms in different countries. Using current FDI statistics for testing scientific hypotheses in this area has become problematic.
- It caused the situation that two partner countries can both record the same transaction as outward FDI.
- For statisticians, it caused the loss of mirror symmetry between inward and outward FDI stocks as a valid statistical consistency check.
- BPM6 causes frequent reports of negative FDI stocks, which only reflects financing decisions, often in the context of tax avoidance constructions.
- FDI statistics do no longer signal a country's attractiveness for locating real foreign investment.
- BPM6 has weakened the relation of FDI statistics with real firm activity in goods and non-financial services markets. It has also weakened the relation of FDI with national accounts data on domestic investment and capital stock accumulation.
- Under BPM6, the distinctions between the three most important sections of the balance-of-payments capital account (FDI, portfolio investment, 'other investment') have become blurred, as current FDI statistics have turned into pure financial data.

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 17 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 definition of FDI, and solve the liability information issue in another way. It seems time to change tack. However, the signs are not promising for the preparations of BPM7 that will be introduced in 2025 (cf. Ohtsuka *et al*., 2022). Are we going to face another 15 years of bad FDI statistics?

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Availability of the UIFS4 database of bilateral FDI stocks, 2001-2022: upon publication of this paper, the database and its documentation will be made available by the author on demand (contact: hlmk@kvl-epr.eu).

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