Looking through conduit FDI in search of ultimate investors – a probabilistic approach

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This paper presents a novel computational method to determine the distribution of ultimate investors in bilateral FDI stock. The approach employs results from the probabilistic theory of absorbing Markov chains. The method allows for the estimation of a bilateral matrix that provides inward positions by ultimate counterparts for over 100 recipient countries, covering 95% of total FDI stock and including many developing countries. Reconstructing the global FDI network by ultimate investors enables a more accurate and complete snapshot of international production than do standalone bilateral FDI statistics. This has considerable implications for policymaking. It also provides more nuanced context to some contemporary developments such as the trade tensions between the United States, China and others, as well as Brexit.

Keywords: ultimate investors, bilateral FDI, conduit FDI, international production, absorbing Markov chains.

1. Introduction

1.1 International production and the challenge of ultimate investors

For many years multinational enterprises (MNEs) established their international production presence predominantly through foreign direct investment (FDI), building an internalized system of foreign affiliates directly owned and managed by the parent company. Today's globalized production, however, is much more diversified. Companies can exert control over a foreign business through non-equity modes (NEMs) of international production, such as contract manufacturing or services

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outsourcing (*World Investment Report*, 2011). The deepening of global value chains has also greatly expanded, fragmented and blurred the traditional sphere of influence of MNEs (from equity-based control to network-based coordination) (*World Investment Report*, 2013; Zhan et al., 2013). At the same time, the 'classic' motivations for MNEs' foreign investment (*resource-seeking, efficiency-seeking, market-seeking*) have broadened, with the scope for financial and tax-driven operations growing (*World Investment Report*, 2015; Bolwijn et al., 2018). FDI financialization, in turn, has resulted in increased complexity in MNE ownership relationships, with the creation of ever deeper and more convoluted corporate structures (*World Investment Report*, 2016). The proliferation and hybridization of modes of international production have been considerably facilitated by digitalization and the rise of intangibles, which have made international business much 'lighter', hence more flexible and mobile (*World Investment Report*, 2017; Casella and Formenti, 2018). These trends have all emerged or been powerfully intensified over the last twenty years, marking *complexity* as a defining feature of the current context of international production.

One of the great challenges for the international community in this context is to devise meaningful ways to describe and measure international production, a necessary condition to inform effective policymaking for inclusive and sustainable development (*World Investment Report*, 2012, 2014). Such analytical efforts require ever richer and more diversified data equipment. In recent years, UNCTAD has complemented its core database of FDI statistics from the national Balance of Payments (BoP) with other data sources such as GVC and value-added trade data (UNCTAD-Eora GVC database),[1] firm level data (from commercial databases, ORBIS Bureau Van Dijk and Refinitiv), project-level data on FDI greenfield projects and cross-border mergers and acquisitions (from fDi Markets and Refinitiv, respectively), and survey-based data (foreign affiliates statistics, mainly from Eurostat and the United States Bureau of Economic Analysis). Nevertheless, FDI statistics from the BoP remain the backbone of most empirical analysis on international production. For many developing countries they are the only available data on the activity of MNEs.

Discussion is ongoing on the extent to which FDI statistics effectively describe the international presence and operations of MNEs (for some references, see section 1.2). A recent paper (Casella, 2019), takes stock of this debate and discusses the pros and cons of using FDI statistics to describe international production. In particular, it argues that the impact of conduit FDI on bilateral FDI positions is a major barrier to a reconciliation between FDI statistics and international production. The main goal of this paper is to make a contribution to overcome this barrier.

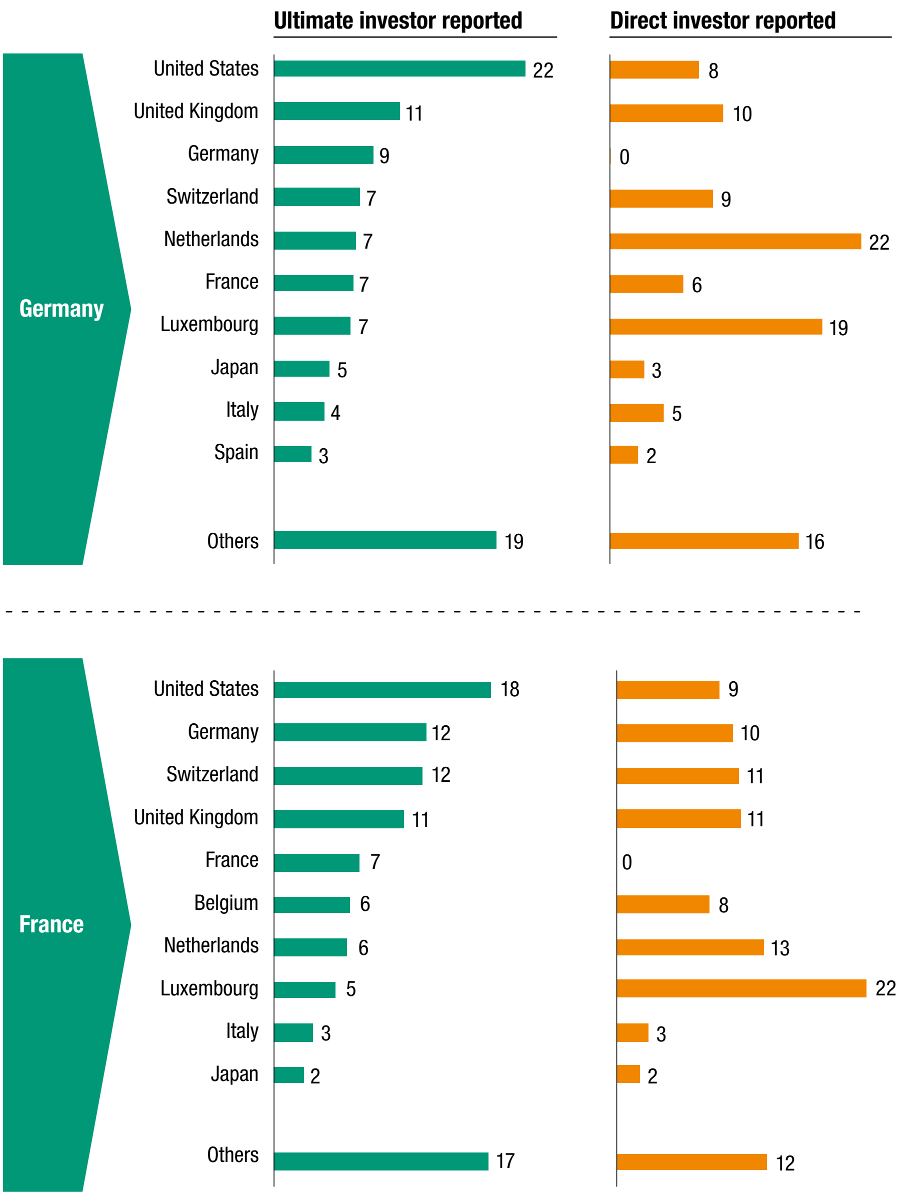
[1] http://worldmrio.com/unctadgvc/

Conduit FDI arises when an MNE investing from home country A in host country B establishes an intermediate step through a third country C. The investment transits first from A to C, and only then, from C to B where it is deployed as productive investment (for example a plant). The intermediate step through C is merely financial, as in country C no real 'productive' investment takes place, and is generally qualified as conduit FDI (but also 'pass-through capital', Borga and Caliandro, 2018; 'indirect FDI', Kalotay, 2012; 'offshore FDI', Haberly and Wójcik, 2015). Most conduit FDI in the world takes place through a limited set of jurisdictions that act as global FDI hubs. These countries allow MNEs to set up Special Purpose Entities (SPEs), which are investment vehicles specifically conceived to optimize MNEs' investment strategies, both from a financial and fiscal perspective. However, a certain limited amount of conduit FDI can take place through operational (non-SPE) entities in standard jurisdictions (Borga and Caliandro, 2018). On the other hand, not all FDI involving offshore investment hubs are conduit or financial (Bolwijn et al., 2018). UNCTAD (*World Investment Report*, 2015; Bolwijn et al., 2018) estimates that between 30% and 50% of total FDI stock is routed through investment hubs as conduit FDI.[2]

A large share of conduit FDI creates a biased picture of international production. In the *inward case* (the direction of the analysis in this paper) not only do conduit FDI inflate inward stock into investment hubs, but they also amplify the role of investment hubs as investors in all other jurisdictions. This is the result of double-counting in the international FDI network: investment does not really originate from the conduit jurisdiction but somewhere else, further up in the investment chain. As a consequence, the increasing role of conduit FDI has widened the gap between bilateral FDI positions by direct investors (as reported by standard bilateral FDI) and those by ultimate investors. Figure 1 shows the problem for France and Germany, two countries that report complementary FDI positions by ultimate investors (currently only fourteen countries provide statistics by ultimate investors; see also figure 2). Compared with the distribution of ultimate investors, bilateral FDI inflates the role of large European investment hubs, such as Luxembourg and the Netherlands, while it depresses the share of some major investor countries such as the United States. What is striking is the magnitude of the gap. For example, the combined share of Luxembourg and the Netherlands makes up 41% of total bilateral FDI in Germany, and the United States only 8%. The ultimate investor view reverts the picture: the share of the United States rises to 21%, and Luxembourg and the Netherlands combined make up only 14% of German inward stock. Similar considerations apply to France and all other countries for which data allow comparison.

[2] This order of magnitude is also confirmed by other studies, such as Haberly and Wójcik (2015).

Figure 1. Comparison between the distributions of ultimate investors and direct investors (Per cent)



Notes: Data from OECD (https://stats.oecd.org), December 2018.

The outcomes illustrated by figure 1 mean standard bilateral FDI data cannot uncover ultimate investor relations. The need for bilateral statistics by ultimate investors as a complement to standard bilateral FDI is now largely acknowledged by the international community. In recent years, as the role of conduit FDI became increasingly unwieldy,[3] there has been growing pressure to report data on ultimate investors. The 2008 OECD Benchmark Definition of Foreign Direct Investment (OECD, 2009) recommends that "*it is strongly encouraged that supplemental inward FDI positions be compiled on an ultimate investing country (UIC) basis*" (page 110). Nevertheless, progress in the reporting of positions based on ultimate investors has been slow. By 2016 data, only fourteen OECD countries reported FDI stock by ultimate investors. Figure 2 shows the current status of reporting and progress made. Notwithstanding the relevance of statistics on ultimate investors for individual countries, the current sample of reporting countries is too limited and developed countries-centred to draw any representative conclusions about ultimate investors at the global level. And, critically, the pace at which developing countries are aligning to recommended standards does not hint at any meaningful progress in the near future.

Against this backdrop, the main question is whether it is possible to estimate the distribution of ultimate investors for a large number of recipient countries, including developing economies. Competent international organizations are actively seeking analytical solutions for this challenging task (see review of the recent studies of the IMF Damgaard and Elkjaer, 2017 and OECD Borga and Caliandro, 2018 in the next section). The transition from reported FDI positions by direct investors to estimated FDI positions by ultimate investors requires: i. To identify the conduit component, i.e. that part of total inward FDI in recipient countries generated by double-counting; ii. To reallocate conduit FDI to genuine investors; this second step implies to find a way to look through conduit FDI, in search of ultimate investors.

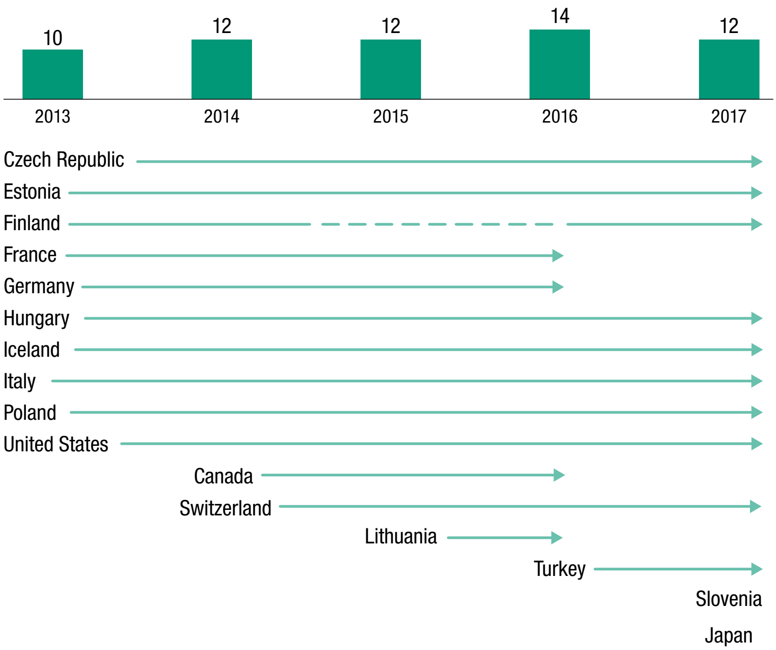
This paper proposes a probabilistic-based methodology to deal with these challenges. The main contribution and the novelty of the approach are to provide a rigorous, analytical way to look through conduit FDI (step ii above), while the identification of the conduit component (step i) is exogenous, relying either on reported data on SPEs (in the spirit of *World Investment Report*, 2015), or on available estimation methods (for example Bolwijn et al., 2018; Damgaard and Elkjaer, 2017; Borga and Caliandro, 2018). The final outcome is a new bilateral matrix providing inward positions by ultimate counterparts for over 100 recipient countries, covering 95% of total FDI stock and including developing countries.

3 UNCTAD *World Investment Report* (2015) estimates an increase of 50% in the share of conduit FDI in just ten years, between the beginning and the end of 2000s.

The availability of a fairly comprehensive picture of ultimate investors opens a range of important analytical and policy applications. Standard bilateral FDI provide an important map of financial relationships between countries, exposing where financial claims and liabilities are created and when they are held. However, when the focus is on international production, the ultimate investor view reveals the relevant underlying patterns: where the investment decision was taken, where the capital originated from, and who bears the risks and reaps the benefits of the investment. This has considerable implications for the actions and policies of countries. For instance, the paper unveils the potential impact of a trade war between U.S. and China on U.S. MNEs intra-firm trade. According to 2016 inward FDI statistics reported by China, the U.S. share of total Chinese FDI stock is a meagre 3%. Yet, the reconstruction by ultimate investors establishes the U.S. as the biggest foreign investor in China, with a 12% share of total inward Chinese stock. The underlying exposure of U.S. firms to U.S. trade barriers on China therefore only becomes evident when inward Chinese investment is seen through the lens of ultimate investors.

Figure 2. FDI positions by ultimate investors: status of reporting

(Number of countries)



Notes: Status as reported by the OECD (https://stats.oecd.org). Other countries reporting data on ultimate investors include the United Kingdom (not reflected by OECD statistics, but see https://www.ons.gov.uk). Brazil also reports some information on ultimate investors up to 2015 in its latest FDI report, but has no publicly available data (see https://www.bcb.gov.br/Rex/CensoCE/ingl/FDIReport2016.pdf).

1.2 Literature review

A key motivation of this paper is to improve the consistency between FDI statistics and the 'real' dynamics of international production. Concerns about the inadequacy of FDI statistics have been raised by Lipsey (2007), Beugelsdijk et al. (2010), Leino and Ali-Yrkkö (2014), and Blanchard and Acalin (2016). On the other hand, Wacker (2013) and Casella (2019) support the (cautious) use of FDI statistics to analyse patterns of international production. Fukui and Lakatos (2012), Ramondo and Rodriguez-Clare (2013) and Federico (2016) effectively employ FDI statistics to impute missing data of foreign affiliates operations, in efforts to build comprehensive databases of multinational production. FDI statistics are also found to be linked to other meaningful measures of international production such as GVC-related indicators (Zhan et al., 2013; Martínez-Galán and Fontoura, 2019).

In a BoP context, the problem of conduit FDI has been analysed by *World Investment Report* (2015), Haberly and Wójcik (2015), Bolwijn et al. (2018) and Janský and Palanský (2018). These studies arrive at similar estimates of the size of conduit FDI – in the range of 30% to 50% of total FDI stock. The emphasis in these studies is on the link between the conduit jurisdictions and the destination countries where operations take place (and profit shifting potentially occurs). For example, Bolwijn et al. (2018) estimate that exposure to conduit FDI from offshore investment hubs is responsible for a loss of government revenues for developing countries in the order of $100 billion annually, as a consequence BEPS (base erosion and profit shifting). These analyses do not go beyond the conduit component to address the problem of the 'real' origin of the investment.

Firm-level literature has also made important contributions to the research on conduit FDI in the context of the analysis of complex corporate structures. UNCTAD firm-level analysis in the *World Investment Report* (2016) shows that about 40% of foreign affiliates are part of multi-step ownership chains involving shareholders from different countries (i.e. they have *multiple passports*), a number consistent with the estimated share of conduit FDI discussed above. Multi-passport entities are responsible for *investor nationality mismatches*, a notion recalling the challenge of the ultimate investors at the firm-level (*World Investment Report*, 2016; Alabrese and Casella, 2019). The increasing availability of firm-level data on ownership structures and relationships has allowed for network theory and big data algorithms to be applied to map corporate networks of ownership and control at a massive, global scale (Vitali et al., 2011; Rungi et al., 2017; Garcia-Bernardo et al., 2017). The study of Garcia-Bernardo et al. (2017) is particularly relevant because of its emphasis on the role of offshore and conduit jurisdictions, including the useful distinction between *conduit* and *sink* jurisdictions. Finally, firm-level drivers and determinants of complex ownership structures are explored by a large empirical literature.

Since the seminal paper of La Porta et al. (1999), studies have analysed factors influencing the financial and investment choices of MNEs that may in turn affect the structure of ownership chains. Taxation features prominently (Altshuler and Grubert, 2003; Desai et al., 2002, 2006; Mintz and Weichenrieder, 2010; Grubert, 2012), but other considerations also matter, including financing, risk management, policy and institutional issues and even historic accident (Desai et al., 2004, 2003, 2007; Lewellen and Robinson, 2013; Dyreng et al., 2015).

Zooming in on the core subject of this paper – the analysis of ultimate investors' relationships – Kalotay (2012) provides a qualitative review of some relevant statistical and policy challenges. Tissot (2016) advocates for a nationality-based approach to national statistics collection, to complement the current residency-based approach. Interestingly, in the paper of Tissot, the case for integrating standard FDI statistics with consolidated statistics based on the nationality of ultimate investors is motivated by the need to better account for systemic risks and inter-linkages in the global financial system rather than by the desire to analyse international production more accurately. Along the same line of Tissot (2016), in a thorough treatment of pass-through capital, Borga and Caliandro (2018) developed a comprehensive statistical framework for consolidated FDI statistics based on the nationality of MNEs. Their analytical proposal builds on a mixed approach, whereby the share of pass-through capital is estimated using firm-level data from ORBIS and applied to official (outward) FDI statistics to compute an estimate of the amount of conduit FDI at the country-level. The estimation step is affected by significant heterogeneity in ORBIS coverage of firm-level data across countries (with poor or almost no coverage for many developing countries). One very interesting point of the paper is the focus on capital passing through non-SPE entities (in the order of 25% of non-SPE FDI stock, according to the paper estimate), an important and often overlooked analytical element in the treatment of conduit FDI. At the current status, the analytical proposal of Borga and Caliandro covers only the estimation of conduit FDI; however, the possibility to extend the methodology to derive statistics by ultimate investors is mentioned as an avenue for future research.

To my knowledge, one study only, IMF Damgaard and Elkjaer (2017), has taken the analysis of conduit FDI as far as the estimation of an alternative network of bilateral FDI broken down by ultimate investors. The paper makes three important contributions. First, it provides an exhaustive account of the main statistical challenges related to bilateral FDI, namely the presence of large bilateral asymmetries, the role of special purpose entities and the breakdown of FDI by ultimate investing economy. Second, it introduces a way to estimate the SPE component in FDI statistics for countries that do not report such information; this proposal adds to the other available options for the estimation of conduit FDI (e.g. *World Investment Report*, 2015; Bolwijn et al., 2018). Finally, for the first time in the literature, is provided an analytical way to estimate the distribution of ultimate investors.

I will focus on the last point, the most relevant for the purpose of this paper. The main idea of Damgaard and Elkjaer is to assign to each investor (i.e. the counterparts in a inward FDI set-up) an adjustment factor based on twelve countries that report data on ultimate investors (as of 2015). The adjustment factor is the average ratio across the twelve reporting countries between the counterpart's size as direct investor (from standard bilateral FDI) and its size as ultimate investor (from countries' complementary reporting). In other words, for any (reporting) recipient country, the distribution of ultimate investors is calculated from the bilateral FDI statistics, by applying to each counterpart an adjustment factor reflecting the ratio between its weight as direct investor and its weight as ultimate investor, as retrieved from the sample of countries reporting both views.[4] The approach essentially applies to all countries in the world the same relationship between the distribution of bilateral FDI and the distribution of ultimate investors of twelve OECD countries (at most).[5] This extrapolating step has some critical limitations. The role of some jurisdictions to channel conduit FDI may be specific to a recipient country or region (regional hubs).[6] In these cases, adjusting the distribution of all countries in the world as if they behave like the twelve developed countries in the reporting sample would be highly misleading.[7] A second limitation is the caps on the adjustment factors that, for a subset of bilateral positions, may drive the results. The resort to caps is due to the fact that the computation of the adjustment factor is based on a small number

4 For a particular investor, say A, an adjustment factor equal to 1 means that on average the (twelve) reference countries have reported the same amount of investment from A in the standard FDI view and in the view by ultimate investors. In this case, for all other recipient countries outside the reference sample, the amount of FDI from A remains unchanged in the ultimate investor view. An adjustment factor below 1 means that, on average across the reporting sample, A is a larger ultimate investor than direct investor. In this case, bilateral FDI from A will be adjusted upward in the ultimate investor view. Similarly, if the adjustment factor is above 1, bilateral FDI will be adjusted downward in the transition to the view by ultimate investors.

5 Coverage of investors across all twelve reporting recipients is not homogeneous; therefore FDI positions for a specific investor may be reported by only a subset of the twelve countries.

6 The importance of regional hubs is well documented, for example in Haberly and Wójcik (2015).

7 One particularly challenging case, acknowledged also by the authors (page 19), is Hong Kong. As the main offshore hub for Chinese investment, Hong Kong has massive role as direct investor into China and Asian countries in general but it is expected to be less relevant as ultimate investor. However, given that the conduit role of Hong Kong is limited in the context of OECD countries, the adjustment factor calculated by Damgaard and Elkjaer is close to 1, i.e. it does not differentiate substantially between Hong Kong as direct investor and as ultimate investor. In other words, in the case of Hong Kong, the method fails to look through, missing out one of the most relevant conduit structures in the global economy. Based on the data accompanying the paper, the estimated share of Hong Kong as ultimate investor in China is 46% of total investment in China, a very large share, not substantially different from its share as direct investor, as reported by China, at 48%. The link between Hong Kong and China is not the only important conduit link involving investment to developing countries, potentially not captured by a view driven by OECD countries. Others include for example jurisdictions like Singapore (conduit to Asian countries) or Mauritius (to African countries and India).

of countries, hence it is exposed to outliers owing to country specificities.[8] Finally, tailoring the estimation so closely to the countries already reporting the distribution of ultimate investors raises questions about the validation procedure based on reported data (estimates may closely match reported data by construction).

* * *

The proposal I present in this paper is based on a different and original approach. It taps into the fact that bilateral FDI data, available for a large set of countries, provide the one-step (or direct) distribution in the investment chain. The combination of these distributions and the (exogenous) assumptions on conduit FDI provides a transition rule to link backward final recipient countries to ultimate investors, effectively looking through conduit FDI. In a nutshell, FDI distributions provide the overall exposure of a recipient country j to direct investment from an investor country i, while assumptions on conduit FDI define whether direct investor i is an intermediate or an ultimate investor. In the former case, the investment process iterates until an ultimate investor arises. Framing this simple idea within the probabilistic setting of absorbing Markov chains allows to analytically derive the distribution of ultimate investors. The main intuition behind the approach as well as its formal elaboration are presented in section 2, the core part of the paper. Importantly, this approach is independent from reported statistics on ultimate investors, i.e. it is not driven by a limited sample of developed countries.[9] Instead, reported distributions on ultimate investors are employed for a validation of the methodology, with promising results (section 3). Due to its novelty, this approach is susceptible to significant future refinements; some possible directions are outlined in section 4. The policy implications are potentially far-reaching, as argued in the concluding section (section 5).

[8] The paper mentions two different caps on adjustment factors. i. A cap between 0.33 and 3 applying to all standard jurisdictions to avoid extreme adjustments; ii. A cap between 0.2 and 1, applying to low-tax economies, to limit their size as ultimate investors.

[9] This is an important improvement on Damgaard and Elkjaer (2017). For example, unlike their paper (but in agreement with the expectations), the estimated share of Hong Kong as ultimate investor in China, at 12%, is substantially lower than its share as direct investor at 48% (see also discussion in footnote 7).

2. A new approach to determine the distribution of the ultimate investors

2.1 A simulation exercise

For illustrative purposes, I first present the main idea of the paper in a simplified simulated setting.

Suppose the presence of five (recipient) countries A, B, C, D and E, with two sets of information. (i) First, the bilateral FDI reported by each recipient country; (ii) Second, some prior information on conduit FDI. For example, assume that countries D and E are always conduit jurisdictions, i.e. intermediate steps in a long investment chain; on the other hand, the three remaining countries A, B and C are always the origin of the investment (non-conduit).

The simulation exercise consists of using (i) bilateral information on direct investors and (ii) assumptions on conduit jurisdictions, to trace back the chain of investment from the final ('lowest') recipient up to the ultimate ('highest') investor. Starting from the recipient country j (any country A, B, C, D, E), the simulation employs the distribution of bilateral FDI reported by j to simulate a direct investor i. If the direct investor is a conduit jurisdiction (i = D or E), it iterates the process with country i now acting as reporting recipient: a direct investor to i will be simulated from the distribution of bilateral FDI reported by i, adding an upper layer in the investment chain. If the direct investor is a non-conduit jurisdiction (i = A, B or C), the investment chain stops and the highest simulated direct investor coincides with the ultimate investor. In this simplified setting, ultimate investors can only be the non-conduit jurisdictions A, B and C. I will refer to this process as the *reversed investment process*, because it reverts the usual 'top-down' investment direction (from the investor to the recipient). Figure 3 illustrates the dynamics of the reversed investment process.

Applying a standard Monte Carlo approach (Robert and Casella, 2004) will provide for any country j a suitable approximation $\hat{p}$ of the distribution of its ultimate investors i, say $p^u(j, i)$, as the number N of iterations becomes larger:

$$p^u(j,i) \approx \hat{p}^u(j,i) = \frac{\sum_{n=1}^{n=N} \mathbb{I}_n\{i \overset{ULT}{\Longrightarrow} j\}}{\mathrm{N}}, \qquad i = A, B, ..., E \tag{1}$$

where $\{i \overset{ULT}{\Longrightarrow} j\}$ is the event that country i is ultimate investor to the recipient country j and $\mathbb{I}_n\{A\}$ is an indicator function taking value 1 if event A occurs at the n-th trial of the simulation, otherwise it takes value 0. By construction of the simulation process, $\hat{p}^u$ is positive when investor countries i are non-conduit (A, B, C) and 0 for conduit jurisdictions (i=D, E). Also, $\hat{p}^u$ respects the unit condition of probability distributions, i.e. $\sum_i \hat{p}^u\ (j,i) = 1$, as required.

I now relax assumption (ii) on conduit FDI. Instead of dividing *jurisdictions* in conduit and non-conduit, the simulation allows for a conduit component in each country (figure 4). In other words, for each direct investor country i, a known share of investment is made through conduit entities (for example SPEs). This approach is more realistic because even in large offshore investment hubs there may be a (limited) portion of 'original' investment (Bolwijn et al., 2018); and, vice versa, standard jurisdiction can be occasionally used to channel pass-through investment (Borga and Caliandro, 2018). The first simulation (figure 3) is a special case, where the conduit share can only be equal to 0 (countries A, B and C) or 1 (countries D and E).

The simulation of the reversed investment process in this more general setting requires an additional step. Every time a direct investor i is sampled, the process simulates its conduit status from a 0-1 (Bernoulli) distribution ('conduit' – 'non-conduit'). If the outcome is 'conduit', a further direct investor is sampled, otherwise the simulation stops and the highest direct investor coincides with the ultimate investor. Unlike the first simulation, ultimate investors can be any country A, B, C, D, E. Application of Monte Carlo (1) then provides a suitable approximation of the distribution of ultimate investors.

Figure 3. Simulation of the reversed investment process with binary conduit status

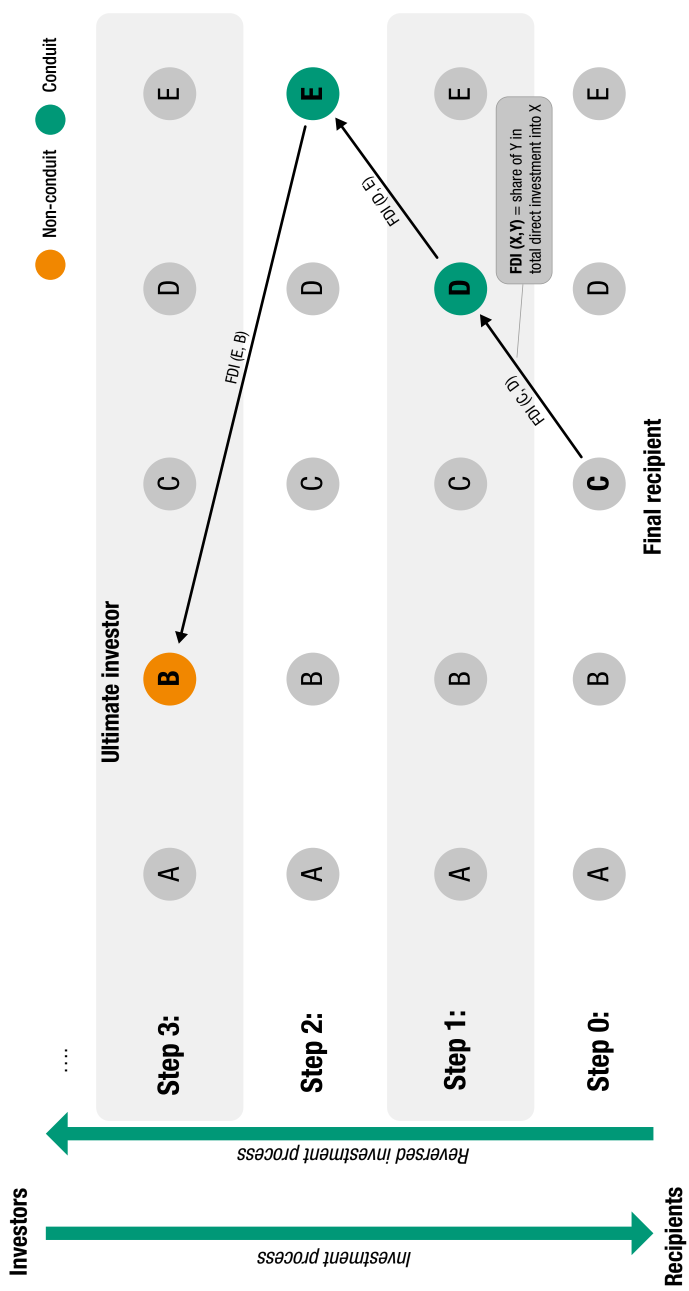
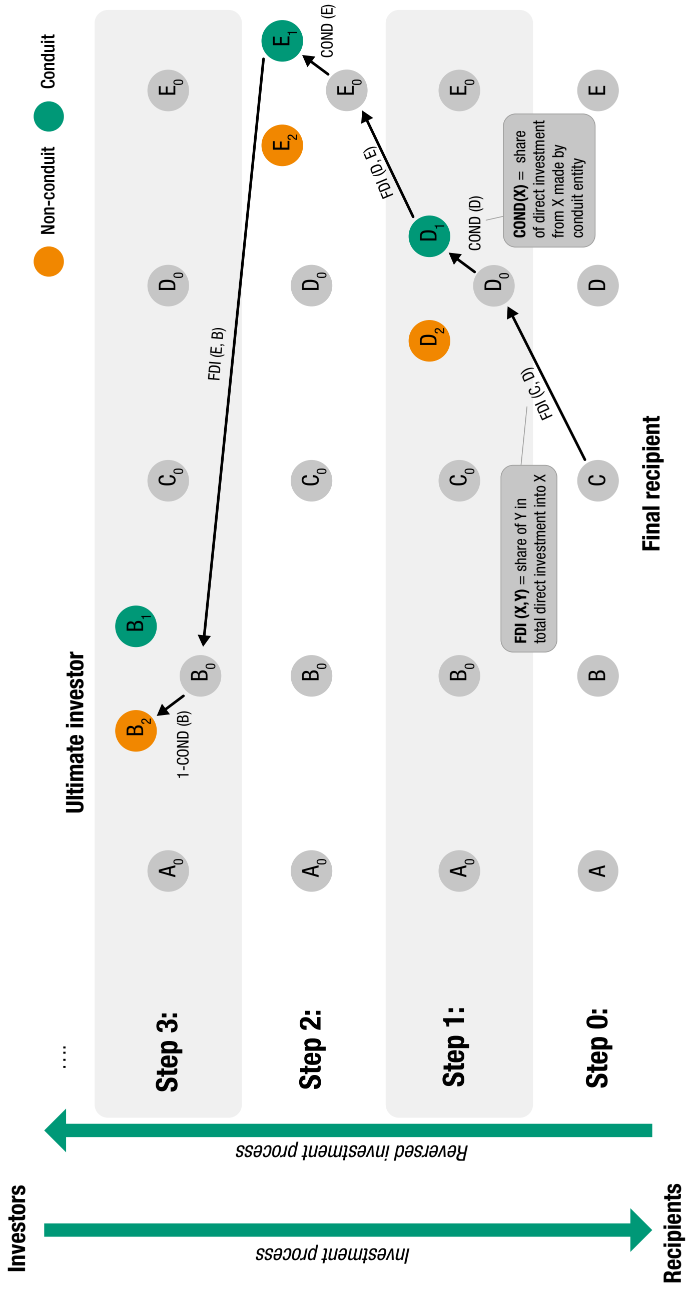


Figure 4. Simulation of the reversed investment process with conduit probabilities



2.2 Preliminaries: Absorbing Markov chains

This section provides a friendly introduction to the theory of absorbing Markov chains, strictly limited to the elements relevant for application in this paper. A more comprehensive and rigorous background can be found in many textbooks on stochastic processes, for example Grinstead and Snell (1997) (chapter 11), for a basic reading, or Stroock (2005) for a more advanced treatment.

Definition 1 (Markov chain). A Markov chain is a sequence of random variables (a stochastic process) in a discrete time frame $\{X_n\}_{n=1, 2,...}$ satisfying the following *Markov property*:

$$\Pr(X_{n+1} = x_{n+1} \mid X_0, X_1, ..., X_n) = \Pr(X_{n+1} = x_{n+1} \mid X_n),$$

for any $n=0, 1,...$ (2)

The probability distribution defined by (2) is called *transition probability*. The Markov property states the defining feature of Markov chains: at any step n, the behavior of the process at the further iteration $(n+1)$ depends only on the current state X_n. The history of the process $\{X_0, X_1,..., X_{n-1}\}$ does not have any impact on its future behavior X_{n+1}, *given* the knowledge of its current status X_n.[10] For this reason, Markov processes are also said to be *memoryless*. The underlying idea is that the present status condenses all the past information needed to predict the future behavior of the process.

A Markov chain is *homogeneous* when the transition probability (2) is the same for all n (i.e. it does not depend on the 'time'). Formally:

$$\Pr(X_{n+1} = a \mid X_n = b) = \Pr(X_n = a \mid X_{n-1} = b) = p(a; b),$$

for any $n=1, 2,...$ (3)

[10] Here the familiar categories of 'past', 'present' and 'future' are used for descriptive purposes but do not necessarily refer to physical time. Often Markov chains describe phenomena taking place at a (discrete) physical time, but sometimes they just refer to an abstract sequence of events. This characteristic is particularly important in the application of this study (section 2.3) where the sequence described by the relevant Markov chain Xn is not driven by physical time; indeed to some extent it reverts the physical time-flow.

The *state-space* of a Markov chain $\{X_n\}$ is the set of all possible values that the sequence of random variables $X_0, X_1,...$ can take with positive probability. The state-space is finite if the Markov chain can assume only a finite number M of values. As a consequence of (2) and (3), the probabilistic behavior of a homogeneous Markov chain on a finite state-space, say $\{a_1, a_2,..., a_M\}$, is fully determined by an initial condition $\{X_0 = x_0\}$ and a *transition matrix* P with dimension $[M \times M]$ and generic elements $\{p\,(a_k;a_h)\}_{k,\,h=1,\,2,...,\,M}$ defined by (3). The rows of the transition matrix P identify the current state while the columns identify the next state; the elements of the matrix are the probabilities to move from a given current state to any next state.

A state a_j of a Markov chain is called *absorbing* if it is impossible to leave it, i.e. it satisfies:

$$Pr\,(X_{n+1} = a_i \mid X_n = a_j) = 0,$$

for any $i \neq j$ and any $n = 0, 1,...$ (4)

In Markov chains, a state that is not absorbing is defined *transient*.

Definition 2 (absorbing Markov chain). A discrete stochastic process $\{X_n\}_{n=1,\,2,...}$ is an absorbing Markov chain if it satisfies the *Markov property* (2), it has *at least one absorbing state* and if, from every state, it is *possible to reach an absorbing state.*

Definition 3 (standard form of transition matrix). Suppose to have an homogeneous absorbing Markov chain $\{X_n\}$ with finite state space $\{a_1, a_2,..., a_M\}$, such that K states are absorbing and the others $M - K$ are non-absorbing (or transient). Then the transition matrix P is said to be in a standard form if absorbing states precede the transient states in the matrix representation:

$$\mathbf{P} = \begin{array}{c} \\ \text{abs} \\ \\ \text{trans} \end{array} \begin{bmatrix} \text{abs} & \text{trans} \\ \mathbf{I} & \mathbf{0} \\ & \\ \mathbf{R} & \mathbf{Q} \end{bmatrix} \qquad (5)$$

where, by definition, I is a $[K \times K]$ unit matrix, while 0 is a $[K \times (M - K)]$ null matrix. The n-th transition matrix P_n is then defined as:

$$\mathbf{P}_n = \Pr(X_n \mid X_0) = \begin{array}{c} \\ \text{abs} \\ \\ \text{trans} \end{array} \begin{bmatrix} \text{abs} & \text{trans} \\ \mathbf{I} & \mathbf{0} \\ & \\ \mathbf{R}_n & \mathbf{Q}_n \end{bmatrix} \tag{6}$$

The focus here is on the limiting matrix $\mathbf{P}^*$ describing the long-term behavior of $\mathbf{P}_n$, when $n \rightarrow \infty$:

$$\mathbf{P}^* = Pr\{X^* \mid X_0\} = \lim_{n\to\infty} \mathbf{P}_n = \lim_{n\to\infty} \Pr(X_n \mid X_0) \tag{7}$$

Then the key result on the distribution of the limiting transition matrix $\mathbf{P}^*$ follows.

Main result (limiting distribution of absorbing Markov chains). If $\{X_n\}$ is an absorbing Markov chain with transition matrix $\mathbf{P}$ in the standard form (5), then the limiting transition matrix $\mathbf{P}^*$ is given by:

$$\mathbf{P}^* = \Pr(X^* \mid X_0) = \begin{array}{c} \\ \text{abs} \\ \\ \text{trans} \end{array} \begin{bmatrix} \text{abs} & \text{trans} \\ \mathbf{I} & \mathbf{0} \\ & \\ \mathbf{R}^* & \mathbf{0} \end{bmatrix} \tag{8}$$

such that:

$$\mathbf{R}^* = \mathbf{F} * \mathbf{R} := (\mathbf{I} - \mathbf{Q})^{-1} * \mathbf{R} \tag{9}$$

with $\mathbf{R}$ and $\mathbf{Q}$ defined by (5). The matrix $\mathbf{F} := (\mathbf{I} - \mathbf{Q})^{-1}$ is called the *fundamental matrix* of the absorbing Markov chain $\{X_n\}$. The result (8) and (9) provides a nice and simple characterization of the long-term behavior of an absorbing Markov chain $\{X_n\}$. It implies that the Markov chain will always be absorbed in the long-run (it will end up in one absorbing state with probability 1) and it provides the probability of each absorbing state, given any possible starting state (transient, by definition).

This result will be the key to determine the distribution of ultimate investors in the application to bilateral FDI stock presented in the next section.

2.3 Harnessing Markov chains to locate ultimate investors

Main proposition

This section leverages some of the results from the probabilistic theory of absorbing Markov chains to compute the distribution of ultimate investors in bilateral FDI positions. The main proposition is the same as illustrated by the simulation exercise in section 2.1, i.e. to use (i) bilateral FDI and (ii) assumptions on conduit FDI to define a suitable and realistic transition rule linking backward recipient countries to ultimate investor countries. Remarkably, while simulation is a useful and intuitive way to approach this problem, the actual computation of the distribution of ultimate investors does not require simulation and Monte Carlo (1) but it can be derived analytically. This derivation is the main objective of this section.

As a first step, the reversed investment process, introduced in section 2.1 (in particular the version of figure 4), has to be reframed and formalized within the probabilistic setting of absorbing Markov chains (section 2.2). It is important to state ahead that this approach is only *instrumentally probabilistic*. Probability theory is used here merely to address a computational problem: the procedure does not require any probabilistic assumption regarding the 'future states of the world'. Likewise, no formal definition of a probability space (Ω, F, P) is needed to perform a purely computational task.

I model the reversed investment process as a Markov chain, say $\{X_n\}$. The initial state of the chain $X_0 = x_0$ is the recipient country of the investment (or final destination). X_1 is the direct (or immediate) investor country into X_0; X_2 is the direct investor into X_1. More generally, X_{n+1} is the direct investor into X_n. Intuitively, the ultimate investors in X_0 will be a set of countries, say X^u, acting as steady or limiting states for the process; formally, for any given investment path $\{X_0 = x_0, X_1 = x_1, X_2 = x_2, \ldots\}$, there exists n such that $x_n = x_{n+h} := X^u$ for all $h = 1, 2, \ldots$. This intuition will become clearer later in the section.

Formalization of the Markov chain

I proceed now to the description of $\{X_n\}$, by defining first the state-space of the process, i.e. the possible values (states) that the variables $\{X_n\}$ can take at any step n. Then, I characterize its transition matrix: the set of probabilities governing the transition from one state X_n to the next state X_{n+1}, including conditions at the starting states X_0 to initialize the process.

Let M be the total number of countries in the perimeter of interest; in this context, all countries for which the distribution of the ultimate investors is needed. For each country $i = 1, 2, \dots, M$, the process allows two states, a transient state i_T and an absorbing state i_A. In the logic of the reversed investment process, the two states can be described as follows:

- Transient state i_T := 'country i has a direct investor'
- Absorbing state i_A := 'country i has no direct investor'

At any iteration, the Markov chain $\{X_n\}$ can then take $M \times 2$ different values, each corresponding to one country $i = 1, 2, \dots, M$ and one state, transit (T) or absorbing (A). Thus, the state-space of the Markov chain $\{X_n\}$ is given by $\{i_T, i_A\}_{i=1, 2, \dots, M}$.

I am now ready to define the probabilistic structure of $\{X_n\}$, or equivalently its transition matrix $\mathrm{P} := \Pr(X_{n+1} \mid X_n)$ of dimension $[2M \times 2M]$ with generic element:

$$p_{j,h;i,k} := \Pr(X_{n+1} = i_k \mid X_n = j_h) = \Pr\{i_k \overset{DIR}{\Longrightarrow} j_h\},$$

$$i, j = 1, 2, \dots, M;\ h, k = T, A \qquad (10)$$

where $\{i_k \overset{DIR}{\Longrightarrow} j_h\}$ represents the event that country i in state k is direct investor in recipient country j in state h.

The most convenient way to represent the transition matrix P is through four sub-matrix blocks of dimension $M \times M$:

$$\mathbf{P} = \begin{bmatrix} \mathbf{P}^{A,A} & \mathbf{P}^{A,T} \\ \mathbf{P}^{T,A} & \mathbf{P}^{T,T} \end{bmatrix} = \begin{bmatrix} \begin{pmatrix} p_{1,1}^{A,A} & \cdots & p_{1,M}^{A,A} \\ \vdots & \ddots & \vdots \\ p_{M,1}^{A,A} & \cdots & p_{M,M}^{A,A} \end{pmatrix} & \begin{pmatrix} p_{1,1}^{A,T} & \cdots & p_{1,M}^{A,T} \\ \vdots & \ddots & \vdots \\ p_{M,1}^{A,T} & \cdots & p_{M,M}^{A,T} \end{pmatrix} \\ \begin{pmatrix} p_{1,1}^{T,A} & \cdots & p_{1,M}^{T,A} \\ \vdots & \ddots & \vdots \\ p_{M,1}^{T,A} & \cdots & p_{M,M}^{T,A} \end{pmatrix} & \begin{pmatrix} p_{1,1}^{T,T} & \cdots & p_{1,M}^{T,T} \\ \vdots & \ddots & \vdots \\ p_{M,1}^{T,T} & \cdots & p_{M,M}^{T,T} \end{pmatrix} \end{bmatrix} \qquad (11)$$

with generic elements defined, for any row j and column i, as follows:

$$p_{j,i}^{A,A} := p_{j,A;i,A} = \Pr\{i_A \overset{DIR}{\Longrightarrow} j_A\} = \begin{cases} 1 & \text{if } \; i = j; \\ 0 & \text{otherwise} \end{cases} \tag{12}$$

$$p_{j,i}^{A,T} := p_{j,A;i,T} = \Pr\{i_T \overset{DIR}{\Longrightarrow} j_A\} = 0 \tag{13}$$

$$p_{j,i}^{T,A} := p_{j,T;i,A} = \Pr\{i_A \overset{DIR}{\Longrightarrow} j_T\} = p_d\,(j,i)\,(1 - p_c(i)) \tag{14}$$

$$p_{j,i}^{T,T} := p_{j,T;i,T} = \Pr\{i_T \overset{DIR}{\Longrightarrow} j_T\} = p_d\,(j,i)\;\; p_c(i) \tag{15}$$

In (12) – (15), for any country $i, j = 1, 2, \ldots, M$, $p_d\,(j, i)$ defines the probability that country i is direct investor in recipient country j (*direct investment probability of* i *given* j) and $p_c(i)$ is the probability that direct investment from country i occurs through a conduit entity, or equivalently, that country i is in a conduit state (*conduit probability of* i):

a. *Direct investment probability of* i *given* j:

$$p_d(j,i) := \Pr\{X_{n+1} = i \mid X_n = j\} = \Pr \;\; \{\text{Country } i \text{ is a direct investor in recipient } j\} \tag{16}$$

b. *Conduit probability of* i:

$$p_c(i) := \Pr\{X_{n+1} = i_T \mid X_{n+1} = i\} = \Pr \;\; \{\text{Direct investment from country } i \text{ is conduit}\} \tag{17}$$

From equations (12) and (13), when the reversed investment process reaches an investor country j in an absorbing state A, it stops there with country j qualifying as ultimate investor. Instead, equations (14) and (15) describe the transition of the process in presence of conduit states. When investor country j at iteration n is conduit, the reversed investment process continues, assigning a positive probability to a foreign direct investor (i into j) at the upper investment level $n+1$. Such direct investment from country i can be made either by a conduit entity or by a non-conduit entity. The probability of the former is given by (15), as the product between the direct investment probability of i given j, $p_d(j, i)$, and the conduit probability of i, $p_c(i)$. Similarly, the probability that the direct investment from i into j is non-conduit (14) is derived as the product between the direct investment probability of i given j and the complementary of the conduit probability of i, $1 - p_c(i)$. Finally, the definition of the Markov chain $\{X_n\}$ is completed by adding the initial condition:

$$X_0 = j_T, \text{ for any recipient country of interest } j = 1, 2, \ldots, M \tag{18}$$

which ensures that the possible set of initial states is limited to transient states only; this condition is needed in order to initialize the investment process. Notice that the sum of each row in the transition matrix (11), is equal to 1 as required; for any $j = 1, 2, \ldots, M$, from (12) and (14):

$$\sum_{i=1}^{M} p_{j,i}^{A,A} + \sum_{i=1}^{M} p_{j,i}^{A,T} = 1 + 0 = 1 \tag{19}$$

and from (14) and (15):

$$\sum_{i=1}^{M} p_{j,i}^{T,A} + \sum_{i=1}^{M} p_{j,i}^{T,T} = \sum_{i=1}^{M} p_d(j,i) * (1 - p_c(i)) + \sum_{i=1}^{M} p_d(j,i) * p_c(i) = \sum_{i=1}^{M} p_d(j,i) = 1 \tag{20}$$

The key result

Expressions (12) to (15) define an absorbing Markov chain, with a transition matrix $\mathbf{P}$ (11) in the same standard form as (5):

$$\mathbf{P} = \begin{bmatrix} \mathbf{P}^{A,A} & \mathbf{P}^{A,T} \\ \mathbf{P}^{T,A} & \mathbf{P}^{T,T} \end{bmatrix} = \begin{bmatrix} \mathbf{P}^{A,A} \equiv \mathbf{I} & \mathbf{P}^{A,T} \equiv \mathbf{0} \\ \mathbf{P}^{T,A} \equiv \mathbf{R} & \mathbf{P}^{T,T} \equiv \mathbf{Q} \end{bmatrix} \tag{21}$$

From (8) and (9) the long-run distribution of the Markov chain $\{X_n\}$ is given by:

$$\mathbf{P}^* = \Pr(X^* \mid X_0) = \begin{array}{c} \\ \text{abs} \\ \\ \text{trans} \end{array} \begin{bmatrix} \text{abs} & \text{trans} \\ \mathbf{I} & \mathbf{0} \\ & \\ \mathbf{R}^* & \mathbf{0} \end{bmatrix} \tag{22}$$

where $\mathbf{R}^* = \mathbf{F} * \mathbf{P}^{T,A}$ and $\mathbf{F}$ is the fundamental matrix of the Markov chain defined by (9):

$$\mathbf{F} := \left(\mathbf{I} - \mathbf{P}^{T,T}\right)^{-1} \tag{23}$$

The rows of the matrix are the initial states X_O (recipient countries); the columns are the final states X^* (ultimate investors). The interpretation of the limiting matrix $\mathbf{P}^*$ (22) in terms of the reversed investment process $\{X_n\}$ is the following: from any recipient country $j = 1, 2,..., M,$ after a sufficiently large number of (reversed) investment steps, the process will select an ultimate investor (modelled as an absorbing state) with probability 1 (blocks $\mathbf{I}$ and $\mathbf{R}^*$ in the left side of the matrix (22)). The initial condition (18) limiting X_O to transient states (blocks $\mathbf{R}^*$ and $\mathbf{0}$ at the bottom of (22)) ensures that the investment process actually moves away from the recipient country, or in other words, that the initial investment link is foreign.

In this context, the sub-matrix $\mathbf{R}^*$ of dimension *[M x M]* is the key result of this approach, providing for each recipient country $j = 1, 2,..., M$ (by row) the distribution of the ultimate investors $i = 1, 2,..., M$ (by columns). Formally,

$$\mathbf{R}^* = \left(\mathbf{I} - \mathbf{P}^{T,T}\right)^{-1} \times \mathbf{P}^{T,A} = \begin{pmatrix} p^*_{1,1} & \cdots & p^*_{1,M} \\ \vdots & \ddots & \vdots \\ p^*_{M,1} & \cdots & p^*_{M,M} \end{pmatrix} \tag{24}$$

where, for any given recipient country j,

$$p^*_{j,i} = Pr\left(X^* = i \mid X_0 = j\right) = Pr\{i \overset{ULT}{\Longrightarrow} j\}, \qquad \text{i=1,2,..., M} \tag{25}$$

defines the probability that country i is its ultimate investor.

3. An empirical application

Parameters: $\hat{p}_d$ *and* $\hat{p}_c$

The purpose of this section is twofold. The first objective is to exemplify how the approach works in concrete applications with real numbers. The second is to validate the approach, providing sound, although preliminary, evidence that results are consistent with reported data on ultimate investors (available for a handful of countries). This application is mainly illustrative; it does not have the ambition to provide the optimal way to compute the distribution of ultimate investors. Yet, it gives a clear indication that the probabilistic method proposed in this paper is a viable option and a promising avenue to obtain a more accurate gauge of ultimate investors. Further research and empirical work to refine both the inputs into, and the settings of, the computational machine are expected to yield further improvements in the results.

The first step of an empirical application is to assign the parameters of the reversed investment process modelled as the Markov chain $\{X_n\}$ (section 2). This essentially means defining the transition matrix (11), according to (12)–(15). While (12) and (13) are given by definition, the valorization of (14) and (15) requires assigning values to $p_d\,(j, i)$ (16) and $p_c(i)$ (17), for all countries i, j in the perimeter of interest.

For the direct investment probability p_d, the obvious available choice is to use investor countries' shares in inward bilateral FDI data. Thus, the parameter $\hat{p}_d$ assigned to the target probability p_d is defined as follows:

$$\hat{p}_d(j,i) = \frac{FDI(j,i)}{\sum_{k=1}^{M} FDI(j,k)} \tag{26}$$

where FDI (j, i) is the amount of FDI reported by recipient country j from investor i. For any recipient country j, $\hat{p}_d\,(j, i)$ represents the share of investment from country i in total FDI stock in country j (as reported by country j).

The treatment of the conduit probability p_c is less straightforward. The application in this section relies on a refined version of the approach to sizing conduit FDI in Bolwijn et al. (2018), combining data on SPEs reported by countries and estimates of the conduit component through the *implied investment method*. The appendix describes the approach in some detail and reports the resulting estimates of conduit probabilities $\hat{p}_c(i)$ (table 1).

Results and validation

I use official inward bilateral FDI stock for 2016 (as reported by UNCTAD, the OECD and the IMF),[11] to assign values to $\hat{p}_d\ (j, i)$ according to (26). The values of the conduit probabilities $\hat{p}_c$ (reported in table 1 in the appendix) are derived from available information on outward SPEs, complemented by estimates from the application of the implied investment method as described in the appendix and in Bolwijn et al. (2018).

The comparison with reported data on ultimate investors allows to appreciate to what extent the methodology contributes to covering the gap – sizable for most recipient countries – between the breakdown of FDI positions by direct investors and by ultimate investors. The analysis is based on FDI positions by direct and ultimate investors reported by the OECD,[12] for twelve countries (Canada, Czech Republic, Estonia, France, Finland, Germany, Hungary, Iceland, Italy, Poland, Switzerland and the United States) with a historic record in reporting data on ultimate investors for at least three years, as of 2016 (see also figure 2).

For six large recipient countries in the sample, figure 5 shows a comparison between the distribution of the ultimate investors reported by the country, the distribution of bilateral FDI (direct investors) and the distribution of the ultimate investors estimated by the probabilistic approach. In all cases, and particularly for Germany, France, Switzerland and the Czech Republic, the estimated distribution proxies the reported distribution of ultimate investors much better than does the distribution of bilateral FDI. In particular, the methodology takes care of the most relevant conduit schemes – such as those involving the Netherlands and Luxembourg – that play a major role in the diversion of bilateral FDI from the origin of the investment. The application of the probabilistic approach re-establishes realistic ranking between the investors, not only aligned with reported data on ultimate investors but also consistent with the economic size of the countries. The results for the other six countries in the benchmark are similar.

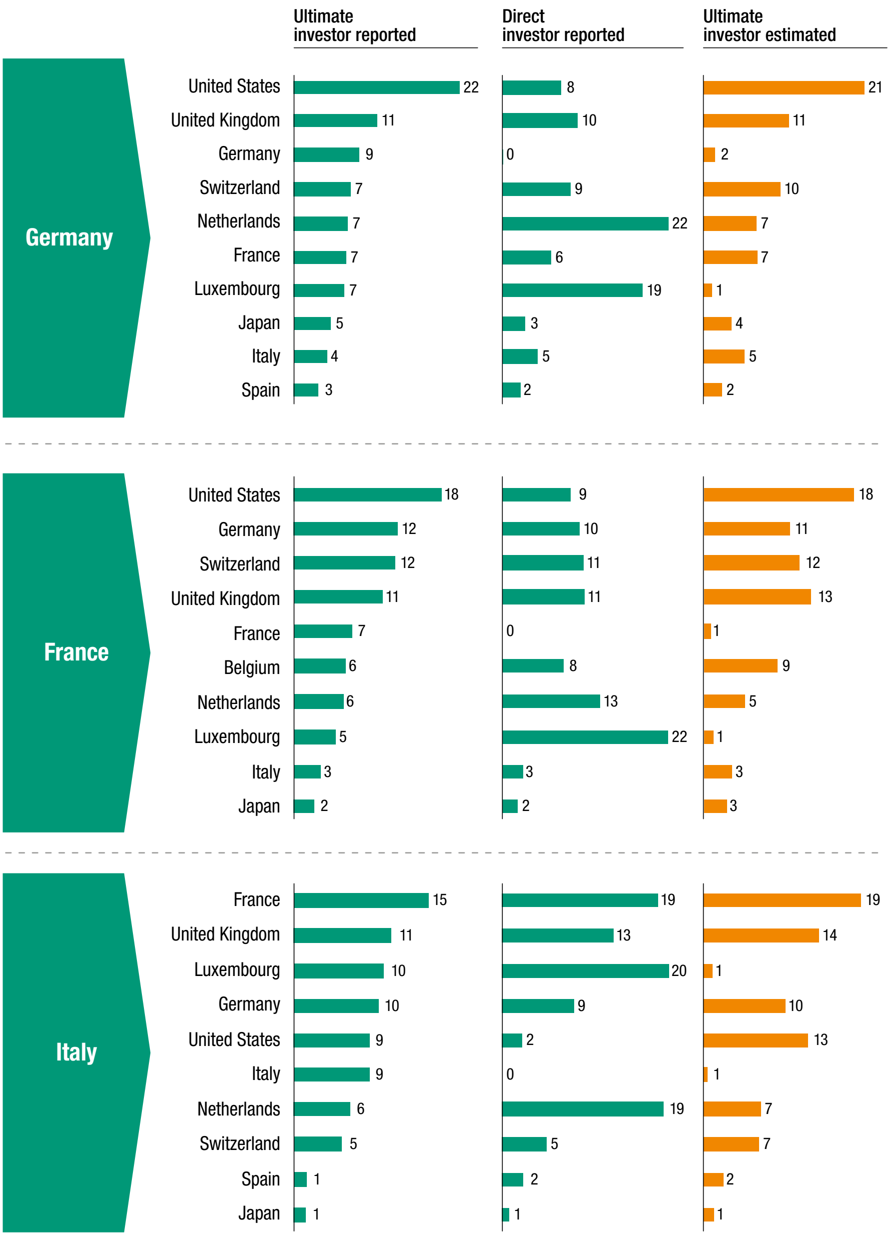
Figure 6 compares for all twelve countries the total variation distance between the distribution of bilateral FDI and the distribution of ultimate investors with the distance between the estimated distribution and the reported distribution of the ultimate investors. For all countries the estimated distribution more closely approximates the reported distribution than standard bilateral FDI. In eight out of twelve cases, the improvement is considerable, with a decrease in total variation distance over 40%.

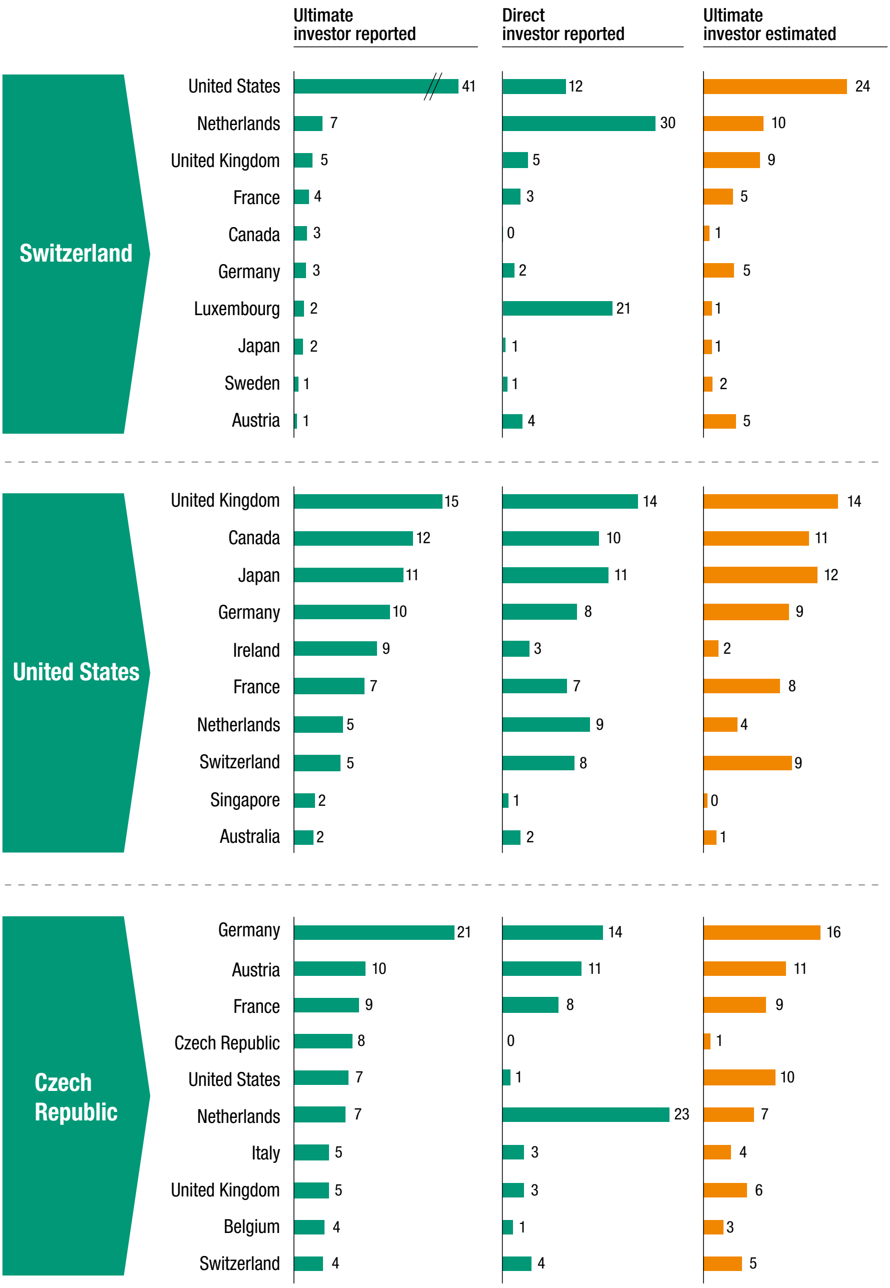
The good results in figures 5 and 6 are even more promising considering the ample scope for refinement of the methodology. Some directions for future improvements are discussed in the next section 4.

[11] Primary source UNCTAD internal data; complemented by OECD statistics (https://stats.oecd.org) and data from IMF Coordinated Direct Investment Surves (http://data.imf.org).

[12] https://stats.oecd.org.

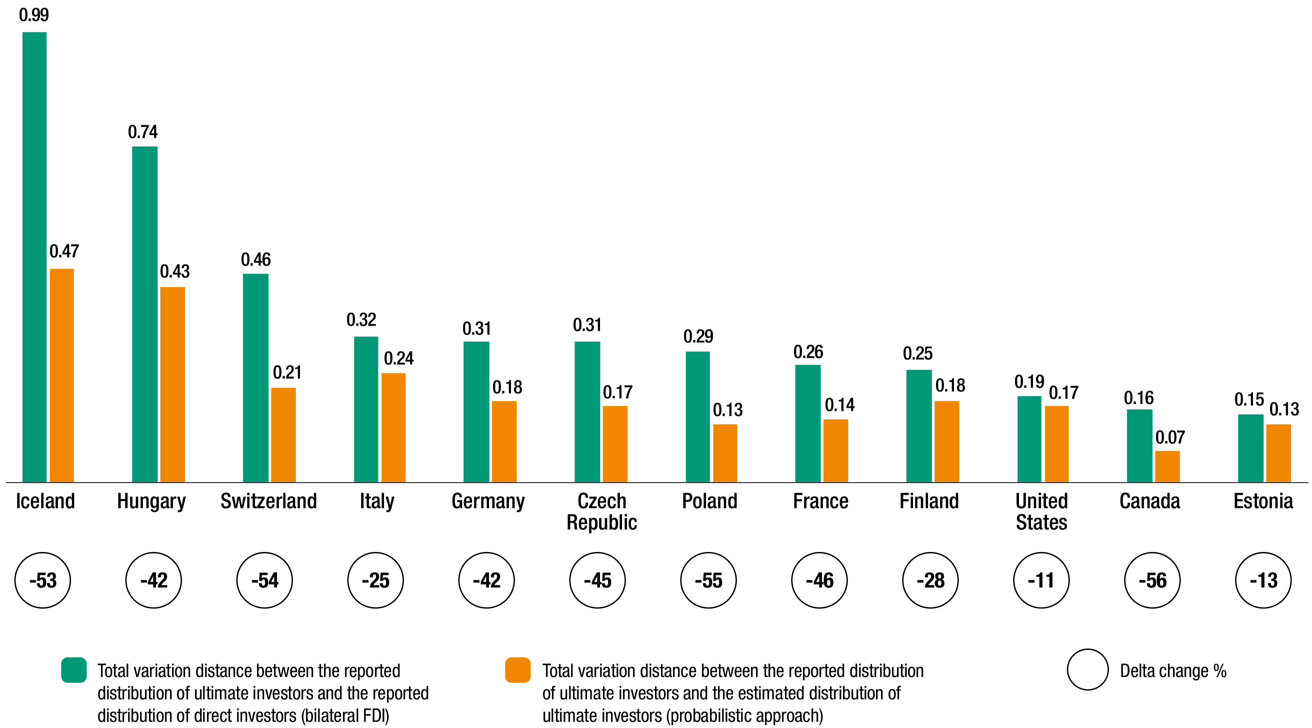
Figure 5. Comparison between reported positions by ultimate investors, reported positions by direct investors (bilateral FDI) and estimated positions by ultimate investors (Selected recipient countries, per cent)





Notes: Reported data on positions by ultimate investors and by direct investors from the OECD (https://stats.oecd.org), December 2018. For each recipient country, the top ten (reported) ultimate investors were selected.

Figure 6. Distance from the reported distribution of ultimate investors: bilateral FDI versus probabilistic approach



Notes: Reported data on positions by ultimate investors and by direct investors from the OECD (https://stats.oecd.org), December 2018. Distance measured in terms of total variation distance. Countries ranked based on the total variation distance between the reported distribution of ultimate investors and the reported distribution of direct investors.

4. Limitations and future directions

Issues: country-specific effects and round-tripping

Notwithstanding encouraging results presented in section 3, figure 5 also exposes some of the limitations of the methodology. A major one is related to the ability to capture country-specific effects. The methodology works well to remove more systematic and cross-cutting ‘conduit noise’ affecting bilateral FDI. However, the approach struggles to capture country-specific issues. An example is the role of Irish investment in the United States. In figure 5, Ireland features as a relatively large ultimate investor in United States, while it is generally considered, and indeed is treated by the methodology, as a conduit jurisdiction. A likely explanation for this effect is the recent wave of *re-domiciliation* of MNE parents from the United States to Ireland as a consequence of tax inversion. In this case, the probabilistic approach, capturing the systemic conduit role of Ireland in international investment, points the computation in the wrong direction, and amplifies the gap with the reported data of ultimate investors. Reassuringly, comparing the distributions across all countries, the anomalies are limited, while the effect of systemic conduit schemes, such as those involving the Netherlands and Luxembourg, is marked. A second issue concerns the treatment of round-tripping. Unlike standard bilateral FDI, the probabilistic approach allows for the possibility of round-tripping. However, the estimates of its share tend to be systematically biased, too small where round-tripping is more relevant (for example in Germany or Italy) or too large where it is relatively limited (United States). In the rest of this section, I will discuss potential remedies for these issues, focusing in particular on two interesting directions of research: the refinement of the calibration of the conduit probabilities and the relaxation of the Markov property to allow path-dependence.

Calibrating conduit probabilities

The main focus of this paper is on the computational machine, i.e. on setting up the modelling approach and the computational procedure that generate a good estimate of the distribution of ultimate investors *given* reasonably realistic inputs. The main inputs in this context are the distribution of direct investors, denoted by p_d, and the probability of conduit investment, p_c. The results’ accuracy depends critically on how well the parameters are assigned. The empirical application of section 3 employs some simple parametrization, whereby $\hat{p}_d$ is derived from bilateral FDI (26) and $\hat{p}_c$ employs a refined version of the approach in Bolwijn et al. (2018) (see appendix). The treatment of $\hat{p}_d$ is not particularly problematic as (26) seems an obvious choice. The second parameter $\hat{p}_c$, the conduit probability, is more challenging and subject to improvement. The approach of Bolwijn et al. (2018) is only one possible way to size conduit FDI;

alternative approaches include *World Investment Report* (2015); Damgaard and Elkjaer (2017); Borga and Caliandro (2018). It would be useful to compare the results of the probabilistic approach across alternative methods. An attractive option could also be to combine the approach in *World Investment Report* (2015) or Bolwijn et al. (2018), focusing on SPE-related conduit FDI, with Borga and Caliandro (2018) targeting conduit investment through operational (non-SPE) entities. Departing from existing methods, bolder options could also be explored. In the current specification, conduit probabilities are assigned at the level of individual investors based on the conduit role that the jurisdiction plays in the overall international investment network. This approach is essentially driven by big numbers. It puts at the centre of the analysis the *global* investment hubs and allows for the major conduit structures – either affecting many recipient countries or some very large ones – to be captured. There are, however, country-specific issues that the method may fail to address. In the case of Irish investment in the United States described above, a jurisdiction (Ireland) that generally behaves as conduit plays the role of ultimate investor for a specific recipient (United States). Vice versa, some investor countries that do not appear as large conduits in the global picture may play that role for a specific recipient. Capturing such country-specific dynamics would require finding a way to estimate conduit probabilities $\hat{p}_c$ not only by investor countries i $(\hat{p}_c(i))$ as in the current formulation, but also by recipient country j $(\hat{p}_c(j,i))$. This would provide a much more granular picture of conduit FDI, and ultimately a more accurate profile of ultimate investors.

Relaxing Markov property to allow path-dependence

Over and above the improvements in the calibration of the parameters, the probabilistic approach itself (the ‘computational machine’) can be tuned. I discuss here one potential direction, dealing with the hypothesis of Markovianity (2). Condition (2) applied to the reversed investment process implies that the distribution of direct investors depends exclusively on the immediate recipient and not on other links downstream in the investment chain. In other words, it requires to ‘forget’ what is already known about the reversed investment process and focus only on the very last step of the Markov chain (the ‘highest investor’). This assumption is particularly useful because it allows for the problem to be framed within the standard analytical setting of Markov chains, significantly reducing the modelling and computational complexity. However, in certain cases, the memoryless feature of Markov chains is particularly restrictive. One notable case is round-tripping, where, in fact, the results of the probabilistic approach tend to poorly match reported data (figure 5). Because of the Markov property, the approach does not recognize round-tripping as a special case. Round-tripping results mechanically when ultimate investors coincide with final recipients. In other words, round-tripping is not treated as a special case, i.e. differently from any other potential realization of the investment process.

This explains the under-estimation of round-tripping for those countries that are more prone to these practices and the over-estimation for countries for which round-tripping is relatively less relevant. Relaxing the Markov property to allow some path-dependence is an option that warrant further consideration, paying attention, however, to the trade-off between the marginal improvement in the results and the increase in computational and modelling complexity. Another, more pragmatic, option to deal with round-tripping is to assign a round-tripping probability *ex-ante*, aside from the computational approach, based on outside-in information on the individual countries (there is quite rich anecdotal and country-specific information on round-tripping, see for example Geng, 2004; Ledyaeva et al., 2015).

5. Conclusions and policy implications

This paper proposes a methodology to compute the distribution of ultimate investors for the set of recipient countries covered by inward bilateral FDI (including more than 100 countries, exceeding 95% of total FDI stock). The approach combines the information provided by bilateral FDI with assumptions on conduit investment to link final recipients and ultimate investors (reversed investment process). The investment dynamics implied by the reversed investment process can be modelled as an absorbing Markov chain where the absorbing states act as ultimate investors. For each starting point (recipient country), the limiting probability of absorbing states – analitically available – corresponds to the target distribution of ultimate investors. Comparison with the actual distribution of ultimate investors for twelve countries reporting this information shows that the methodology effectively looks through the main conduit jurisdictions providing a good approximation of the distribution of ultimate investors.

FDI statistics are first and foremost a picture of economic and financial integration among countries. Together with trade data and, more recently, GVC data they are the key indicators of the positioning of a country in the global economy. In a globalized world, these types of data are the empirical basis for many decisions of economic policy at the national and international level. FDI by ultimate investors add to countries' data equipment a key perspective on the underlying business linkages and 'real' financial and productive inter-dependencies, cleared of the 'noise' generated by financial intermediation. Such a perspective is not only complementary to standard FDI statistics but can, and increasingly does, provide alternative insights. Such insights have key implications for different areas of policymaking including investment and trade policies and international taxation.

One notable example concerns the investment effects of *trade tensions* between the United States and China. The impact on intra-firm trade between United States MNEs and their Chinese foreign affiliates can only be fully appreciated when the exposure of Chinese FDI to United States investors is assessed through the lens of ultimate investors. In fact, the U.S. share of Chinese official inward FDI is low, at 3% of total FDI stock, due to the 'filter' imposed by conduit FDI, particularly through Hong Kong. Reassessing ultimate investors' weight through the probabilistic approach brings the U.S. share to 12%,[13] establishing the United States as the largest global investor in China. Interestingly, in another major international quandary such as Brexit, the ultimate investor analysis points in a different direction. The view by ultimate investor neutralizes the amplifying effect of European conduit jurisdictions and puts in perspective the share of European Union as investor in the United Kingdom, at 32%,[14] a sizable share but lower than the 41% indicated by standard bilateral FDI (2016 data).

More generally, international trade and investment treaties are formulated and scoped based on the nationality of the parties. In investment treaties, the main counterpart to focus on would be the investment decision maker, i.e. the ultimate investor. However, the presence of intermediate jurisdictions augments and blurs the scope of international treaties, producing a *de facto multilateralizing* effect. The *World Investment Report* (2016) argued that up to a third of apparently intra-regional foreign affiliates in major (prospective)[15] mega-regional treaty areas, such as the Trans-Pacific Partnership (TPP), the Transatlantic Trade and Investment Partnership (TTIP) and the Regional Comprehensive Economic Partnership (RCEP), would be ultimately owned by parents outside the region, raising questions about the ultimate beneficiaries of negotiations and treaties. In reality, what often happens is that intermediate investment routes follow the network of bilateral treaties, particularly Double Taxation Treaties (DTTs) and Bilateral Investment Treaties (BITs) – a well documented practice known as 'treaty shopping' (*World Investment Report,* 2016). From the perspective of a country involved in treaty negotiations or monitoring, and particularly for developing countries that are more exposed to the risk of information asymmetry, complete data and information, including on ultimate investors, are key elements for a 'deeper' analysis of investment relations to better inform treaty making. While developing the technical capabilities to collect this type of data, the probabilistic approach presented in this paper can provide reliable and relatively accessible estimates.

Likewise, at the level of national investment policies, any strategy aimed at attracting foreign investment (or boosting outward investment) should rely on a comprehensive view of the overall investment network in which the country is

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[13] Result from the empirical application of the probabilistic approach of section 3.

[14] Result from the empirical application of the probabilistic approach of section 3. Estimated share in line with the share resulting from the data on ultimate investors reported by the UK National Statistics (https://www.ons.gov.uk).

[15] Under discussion at the time of the *WIR16* analysis.

embedded. Such view should go beyond the first layer of immediate investors or recipients and extend to ultimate investors where investment decisions are made (or, correspondingly, final recipients, where the actual productive activity takes place). From a more theoretical but related perspective, policy strategies for attracting FDI have traditionally been grounded in rich econometric literature on FDI drivers and determinants that often use standard bilateral FDI as empirical basis for gravity-type equations. In this context, employing as dependent variable bilateral links based on ultimate investors may lead to additional insights and inputs into investment policymaking.

International taxation is another natural policy area for the application of this study. The most important, although not unique, motivation of conduit FDI is MNE fiscal optimization and international tax avoidance (Bolwijn et al., 2018; Janský and Palanský, 2018). Studies on the link between FDI and tax avoidance focus on the relationship between conduit jurisdictions and recipient countries, and tend to overlook the role of home countries, partly due to a lack of data connecting conduit FDI to ultimate investors. However, as pointed out by the *World Investment Report* (2015), tax avoidance is a systemic issue. It involves offshore hubs that materially provide the legal and financial infrastructure. It affects host countries that are primarily affected by, but sometimes in their attempt to lure investment also complicit to, profit shifting. Tax avoidance also involves the home countries of investors, often because they do not have effective legislation in place to prevent the use of hub-based structures or unintentionally encourage the use of such structures by their MNEs. The view by ultimate investors adds the home country perspective to the puzzle of international taxation and investment. This is an important step towards the effective reform of international tax legislation, requiring a truly multilateral effort, achievable only with the contribution and commitment of all parties involved.

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Appendix. Approach to sizing conduit probabilities

The objective of this appendix is to present the methodology for sizing conduit probabilities employed in the empirical application of section 3. In the context of this paper, the conduit probability of a given jurisdiction i is the probability that outward investment from i are made by a conduit entity (see definition (17) in section 2.3). The approach is essentially a refinement of UNCTAD approach initially introduced in the *World Investment Report* (2015) and further developed by Bolwijn et al. (2018), in the context of the analysis of MNE fiscal contribution and tax avoidance. The methodology is based on a segmentation of jurisdictions based on their conduit and offshore role in the global investment network.

Group 1: Tax havens. A list of 38 small jurisdictions originally defined by the OECD. It includes small countries whose economy is entirely, or almost entirely, dedicated to the provision of offshore financial services.[16] Accordingly, the share of conduit investment in outward stock from these countries (i.e. the conduit probability) is 100%.

Group 2: Other investment hubs. This qualification applies to countries with substantial real economic activity (unlike tax havens) that also act as investment hubs for MNEs owing to a favorable tax and investment regime, typically granted through the option to operate by means of SPEs. Two subsets are identified.

> ***Group 2a. Self-reporting SPEs.*** When countries themselves report outward investment through SPEs, the preferential choice is to use their data to assign the conduit probability. In this case the conduit probability is given by the ratio between outward investment through SPEs and total outward investment, as reported by the countries.
>
> ***Group 2b. Estimated investment hubs.*** When the countries do not report the SPE component, the *implied investment method* provides a way to detect relevant investment hubs and estimate their conduit component. The method is based on the assumption of a linear relationship between GDP and FDI, or in other words, a relationship between the size of an economy and its (inward and outward) investment. Such straightforward relationship (supported by very high correlation coefficients) is broken when jurisdictions with a large share of conduit FDI are involved, because these investment are mainly financial and do not fully translate into GDP creation. A natural way to proceed is then to

[16] Anguilla, Antigua and Barbuda, Aruba, the Bahamas, Bahrain, Belize, Bermuda, British Virgin Islands, Cayman Islands, the Cook Islands, Cyprus, Dominica, Gibraltar, Grenada, Guernsey, Isle of Man, Jersey, Liberia, Liechtenstein, Malta, the Marshall Islands, Mauritius, Monaco, Montserrat, Nauru, Netherlands Antilles, Niue, Panama, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, San Marino, Seychelles, Turks and Caicos Islands, United States Virgin Islands and Vanuatu.

define a band (*confidence interval*) around the regression line corresponding to the normal relationship between GDP (x-axis) and (outward) FDI (y-axis), at a certain sufficiently high probability p. It is assumed that observations lying above the band are over-sized because of significant presence of conduit FDI, hence identifying the large investment hubs. For these hubs, the conduit component responsible for the outsize amount of FDI can be estimated as the delta between the observation and the corresponding upper band of the confidence interval, i.e. the additional FDI component that qualifies the jurisdiction as conduit. (Another, less conservative, option would be to calculate the conduit component as the delta between the observed value and the regression line.)

Group 3. Non-conduit jurisdictions. All jurisdictions that do not fall in the group 1 or 2 are assumed to have no conduit FDI, or equivalently, are assigned a conduit probability equal to 0.

Expression (27) summarizes the parametrization of the conduit probabilities p_c resulting from the application of this approach:

$$\hat{p}_c(i) = \begin{cases} 1 & \text{If } i \text{ is a tax haven (Group 1)} \\ \frac{SPE^{out}(i)}{FDI^{out}(i)} & \text{If } i \text{ reports } \textit{SPEs} \text{ (Group 2a)} \\ \hat{p}_{IMPL}(i) & \text{If } i \text{ is large hub but not reporting } \textit{SPEs} \text{ (Group 2b)} \\ 0 & \text{Otherwise (Group 3)} \end{cases} \tag{27}$$

where $SPE^{out}(i)$ is the total amount of outward investment made by SPEs in country i; $FDI^{out}(i)$ is the total amount of outward FDI from country i. Thus the second row in (27) is the share of investment made by SPEs (conduit entity) in total outward investment from country i, as reported by i. Instead, $\hat{p}_{IMPL}(i)$ in the third row denotes the conduit component estimated through the implied investment method described above.

This approach *improves* on the approach introduced in the *World Investment Report* (2015) and Bolwijn et al. (2018) in two aspects. First, it extends the scope of self-reporting SPEs from four countries (Austria, Hungary, Luxembourg and the Netherlands) to fourteen countries reporting SPEs, fully acknowledging and exploiting all available information (group 2a). Furthermore, it refines the methodology to select and size estimated hubs (group 2b). The original formulation of *World Investment Report* (2015) and Bolwijn et al. (2018) relied on some heuristic criteria to identify large hubs, based on threshold for the ratio between FDI stock and GDP (conveniently set at 1). Once the conduit jurisdictions were identified, then the size of the conduit component was trivially given by the delta between the actual level of FDI and the GDP-implied level as estimated by the regression line. In the current formulation, the selection of the large hubs is based on a more robust statistical approach[17] and the sizing of the conduit component follows directly from the same procedure.

Table 1 provides for each selected conduit jurisdiction the resulting share of conduit FDI (i.e. the conduit probabilities).

Table 1. Conduit probabilities by jurisdiction

Group	Jurisdictions	$\hat{p}_c$ (Per cent)
1. Tax Havens	38 jurisdictions	100
2a. Self-reporting SPEs	Luxembourg	95
	Hungary	87
	Netherlands	73
	Iceland	37
	United Kingdom	21
	Portugal	15
	Denmark	13
	Switzerland	9
	Spain	7
	Estonia	6
	Sweden	5
	Belgium	4
	Norway	2
2b. Estimated hubs	Hong Kong	78
	Ireland	65
	Singapore	57

For group 1: see note 16. For group 2a: the list of reporting jurisdictions and the corresponding shares of outward SPEs is based on 2016 data reported by OECD (https://stats.oecd.org/), as of February 2018. For group 2b: selection of jurisdictions and estimates of conduit probabilities are based on the implied investment method (threshold probability for confidence interval at 0.9) with data for GDP and outward FDI stock from UNCTADStat. For simplicity, estimated investment hubs are limited to large jurisdictions, i. e. in the first quartile in terms of outward stock, covering around 99% of the total FDI stock. For Hong Kong, the estimate of the conduit probability is consistent with the share of business activities in outward FDI reported by Hong Kong national statistics (at 78% of total outward FDI according to the latest data, 2015). Countries not listed in the table are assigned conduit probability equal to 0 (group 3).

[17] The illustrated methodology based on confidence intervals is equivalent to using *studentized residual* for the detection of the outliers, a standard approach to the identification of outliers in a linear regression setting.