Dirty money pushed, dirty money pulled. A gravity analysis of anomalous financial statistics

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Abstract

The applied literature on illicit ("dirty") money flows increasingly uses gravity equations as a workable empirical strategy to control for characteristics of both "source" and "destination" countries. This literature lacks reliable data as well as solid theoretical underpinnings. We contribute in two ways: i) we exploit the theory of portfolio investments to empirically derive a global picture of anomalous (i.e. unpredicted) money flows over time; ii) we correlate these anomalous flows with money laundering determinants. Our results show: i) theoretical based financial gravity models are a sound way to look at "dirty" money flows; ii) non-compliance with international transparency standards affects the probability of observing anomalous flows in global financial data; iii) a global map of risk (i.e., anomalous financial activities) can be derived from official statistics; iv) moving from the notion of "risky countries" to that of "risky financial bilateral flows" allows to better investigate the push and pull factors of anomalous flows. The full dataset of bilateral anomalies in portfolio investment flows resulting from our empirical work is made freely available for further research.

Keywords: Gravity model, financial flows, dirty money, offshore financial centers.

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1 Introduction

"Dirty" money flows impair economic growth and development by diverting resources, encouraging crime and distorting the external sector of the economy (Unger, 2007).[1]

The growing significance that this topic has been gaining over the past decades among both policy makers and scholars gave rise to the need for a deeper understanding of the "grey areas" of global finance which are usually identified as Offshore Financial Centers (OFCs), mainly small island independent States and Territories (characterized by remoteness and a small economic dimension). They may seek to attract financial resources, investments and assets by relaxing financial regulations and/or fiscal regimes, stemming in the worst case in the so-called "Seychelles effect" [2] The costs and benefits of compliance with international Anti-Money Laundering (AML) and financial transparency rules and standards for these countries, together with their particular risk-perception and the effects they may have on the behavior of global financial flows, have been investigated by various scholars (Christensen and Hampton 2007; Picciotto 1999; Masciandaro and Portolano, 2003; Geiger and Wuensch, 2007; Gnutzmann et al., 2010). However, a topic generally overlooked by the relevant literature is the so-called "identity arbitrage" (Vleck, 2009), that is the ability of money - facilitated by offshore corporate vehicles - to disguise and cross borders through licit investment channels, by exploiting the existing "institutional differentials" between countries. As Vleck (2009) demonstrated, at the micro-level identity arbitrage is desired for money laundering and tax avoidance whereas at

[1] Notwithstanding the fact that "dirty" money flows and money laundering (ML) flows are often used as synonyms, they are not the same thing. "Dirty" money flows across countries are likely to represent only one of the possible stages of money laundering activities. These activities consist of many operations of concealment and fractioning of funds to make their illegal source untraceable (Schneider and Windischbauer, 2008). A critical issue concerns the difficulty in distinguishing between economic flows originating from criminal revenues and anomalous flows that may stem from tax evasion or underground economy in general. This is the reason why producing estimates of money laundering (defined as the whole process of "laundering" of profits deriving from criminal activities) is a delicate and risky issue, and will not be the focus of this work. we aim to understand "dirty" money flows by considering them only as one of the phases in money laundering.

[2] Gnutzmann et al. (2010) define as "Seychelles effect" the set of policies that may be implemented by some countries to deliberately invite criminal investment. According to the authors, this derives from the fact that smaller countries need to bear only a small part of the social cost they generate, and provides the theoretical reasoning for the observed variance in AML regimes.

the macro-level it is used for "roundtripping" operations, to turn domestic capital into foreign direct investment (see also Ledyaeva et al., 2015). In this framework what is relevant is not only the quality of regulation in the "destination" country but the interaction between the regulations of both the destination and the origin countries, generating the differentials that allow for "identity arbitrage" of capital. In other words, efforts of policymakers in the origin country to control financial flows through taxation and regulation also establish the motivation for the use of sovereignty and identity arbitrage by encouraging the flight of (illicit) investment capital, exploiting the differentials generated respect to less regulated jurisdictions to gain economic benefit (Vleck, 2009). This is the main reason why a joint analysis of the push and pull factors of licit and illicit money flows across borders is highly recommended to study how the peculiarities of origins and destinations interact, facilitating flows of illicit gains.

In this work, we use the term "dirty" money flows in a broad sense as any "illicit" revenue (also from tax evasion and tax avoidance) flowing across countries. Specifically, we focus on portfolio investment flows since these are a fast way to move capitals around the globe and can actually occur in various phases of money laundering: financial investments can alternatively be used in the layering phase or for placing the money in its final spot . Assets serving this scope are generally low risk, so the chances of losing money are small (European Parliament, 2017). While direct investments are more related to controlling or influencing the decision-making process of the enterprise to which the investment is directed to and are usually associated with long-lasting relationships, portfolio investments are a direct way to access the financial markets, due to their characters of liquidity and flexibility. In this way, illicit funds can be rapidly "dissolved" in the global financial flows and can be very easily converted back into cash. Moreover, laundered funds may often be co-mingled with lawful transactions, making more difficult to trace the exact path of dirty money from source to destination.

Our aim is to propose a workable way to look at the global "illicit flows" by first assessing anomalous bilateral transactions across countries and then looking at the correlations between such anomalies and illicit activities in the country of origin and/or an excessive laxity of financial system regulation and controls in the country of destination. To this end, we follow up the applied literature on illicit/sub-legal financial flows looking at the gravity equation as a natural empirical strategy to estimate the phenomenon controlling for the characteristics of both "source" and "destination" countries. Unfortunately, this literature applied to "dirty" money flows lacks reliable data as well as a solid theoretical underpinnings (see, inter alia, Walker 1999 and Walker and Unger, 2009). Our contribution to this literature is two-fold: i) we rely on the theory of portfolio investment flows (Okawa and van Wincoop, 2013) to empirically derive a global picture of anomalous (i.e. unpredicted) money flows over time; ii) we rely on the literature on money laundering (among the others Walker and Unger, 2009; Cobham et al, 2015) to identify possible correlations between these anomalous flows and their most common determinants.

Since to the best of our knowledge there are no calibrated parameters deriving from an empirical estimation of Okawa and van Wincoop's theoretical model on a global scale, in the first part of our work we run fresh empirical estimates on CPIS (IMF) data, by applying both a Least Square Dummy Variables (LSDV) and a Poisson Pseudo Maximum Likelihood (PPML) specification. We then use the studentized residuals of the above estimates to rank anomalous flows and check the existence of possible nexus with "dirty" money flows and a set of explanatory variables that according to the literature on sub-legal finance and money laundering relate to non-compliance with international transparency standards and AML rules. Our results show that theoretically-based gravity models are a sound and robust way to look at "dirty" money flows than their commonly used *ad hoc* counterparts. Furthermore, we show that non-compliance with international transparency standards affects the probability of observing anomalous flows in global financial data. This work provides two key implications: i) instead of spending time and effort tracing the exact path of "dirty" money flows, we can build a global map of risk (i.e., anomalous financial activities) by simply exploiting official statistics; ii) rather than focusing on "risky countries", we could focus on "‘risky financial bilateral flows"’, and investigate to what measure each destination results attractive to a given origin, according to their respective characteristics. To this end, the full dataset of bilateral anomalies in portfolio investment flows resulting from this work is freely available here as supplementary material for further research. It has unbalanced panel structure and covers the years 2001-2015, including 85 origin and 214 destination countries.

The rest of the paper is organized as follows: Section 2 presents a brief review of the literature on "dirty" money flows and on gravity models of finance; Section 3 shows the empirical strategy; Section 4 illustrates the dataset and some descriptive statistics; Section 5 provides the estimates of the Okawa and Van Wincoop's model and proves the relationship between anomalous financial flows and a set of variables related to "dirty" money flows; Section 6 reports a sensitivity analysis; Section 7 concludes.

2 Gravity models and "dirty" money flows: a literature review

We report here a brief review of the existing gravity frameworks applied to financial flows. Then, we will look at some *ad hoc* gravity applications in the literature on money laundering and, finally, we discuss the strengths and drawbacks of the various approaches.

Starting from a theoretical framework modeling financial flows in a gravity form, Martin and Rey (2004) elaborated a two-country model with an endogenous number of financial assets to explain the role of financial integration in decreasing the cost of capital, the increase of asset prices with investor base and how market size determines international financial flows. Subsequently, Okawa and van Wincoop (2012) presented a gravity framework based on the theory of portfolio investment flows where bilateral financial flows are positively driven by a size factor - that is the total equity holdings of destination and supply of equity of origin countries divided by world demand (supply) - and negatively affected relative frictions, conceived as asymmetric information (Portes et al., 2001 and Portes and Rey, 2004).

A number of scholars have also empirically investigated the determinants of financial flows by applying a gravity framework. Ghosh and Wolf (2000), controlling for other factors in a standard gravity framework, show that location matters also in financial flows. Conversely, Aviat and Coeurdacier (2005), exploring the complementarity between bilateral trade in goods and bilateral asset holdings in a simultaneous gravity equations framework, found that - controlling for trade - the impact of distance on asset holdings is drastically reduced. Buch (2005) who studied whether distance is also a determinant of international banking, found that distance actually has a significant impact on banking flows and that its effect has not quite changed over time. Guerin (2006), focusing on a set of host country characteristics that attract FDI, trade and portfolio investment flows, found a significant difference between North-North and North-South flows, showing that geographical factors have a non-negligible role in explaining the allocation of FDI and portfolio investment flows as well as trade. Lane and Milesi Ferretti (2008) also provided a systematic gravity analysis of the bilateral factors driving portfolio equity holdings across countries. They confirmed bilateral equity holdings to be strongly correlated with bilateral trade in goods and services and that larger bilateral positions are also associated with proxies for informational proximity. Eichengreen and Luengnaruemitchai (2008) focus instead on the Asian context and assess bond markets as a conduit for capital flows using a gravity equation. They analyze the importance of determinants of non-resident holdings of a country's bonds. They compare cross-country holdings in Asia with cross-country holdings in other regions to examine the extent of bond market integration across regions and over time. They found that Europe is significantly above other regions in terms of financial integration, however Asia is a region that is quickly progressing, both compared to Latin America only and to the rest of the world. The contrast with Latin America is largely explained by stronger creditor and investor rights, more expeditious and less costly contract enforcement, and greater transparency that lead to larger and better developed financial systems in Asia. The authors also find evidence that cross-holdings are heavily driven by financial conditions in the investing country, also indicating that bondholders are attracted to the securities of countries whose returns co-vary with their own, suggesting return chasing rather than diversification behavior. As for the European context, Coeurdacier and Martin (2008) analyze the impact of the euro on the determinants of trade in bonds, equity and banking assets. They make use of a theoretical model to disentangle the different effects that the euro may have on cross-border asset holdings for both Eurozone countries and countries outside the Eurozone. They found that it is cheaper for all countries to buy Eurozone assets since internal transaction costs are lower and that there is also a diversion effect due to the fact that lower transaction costs inside the Eurozone imply a reduction of equity purchases from outside. On the other hand, Papaioannou (2008) assesses by means of a gravity equation how institutions and politics affect international capital flows and find that institutional improvements are followed by significant increases in international finance, that there is a strong effect of initial levels of institutional quality on future bank lending and that the historically predetermined component of institutional development is also a significant correlate of international bank inflows. Other studies focus on the role of other social and cultural factors on financial flows. Among others, Aggarwal et al. (2011), incorporating Hofstede's cultural dimensions of individualism, masculinity, power distance and uncertainty avoidance show how cultural traits in both source and destination countries, as well as the cultural distances that separate them, interact with geographic distance and other gravity variables to determine global portfolio investment patterns. They find that while distance always deters investments, aspects of culture and cultural proximity can offset this effect. Along the same lines, Karolyi (2016) conducts an empirical analysis of the role of cultural distance in explaining the foreign bias in international portfolio holdings using traditional gravity model and confirms the importance of taking into account cultural proximity in the estimation of investment flows. All the mentioned studies provide heterogeneous results, but also use different data and methodologies. Table 7 (in Appendix 1) provide a synthesis of the methods and data employed by the afore-mentioned contributions.

Due to the success and convenience of empirical gravity equations in estimating financial flows, some attempts have been made to use them to estimate specifically "dirty" money flows (see, for instance Walker, 1999, partially revised by Walker and Unger, 2009). The latter are gravity equations formulated *ad hoc* for the estimation of "dirty" money flows (Money Laundering in particular) with applications for Australia and the Netherlands. Specifically, Walker (1999) assumes that the share of proceeds from crime generated in country i and sent to country j positively depends on the "attractiveness" of j and negatively on the distance between i and j. The dependent variable in Walker's equation, named F_{ij}, is the amount of "dirty" money flowing from i to j where flows are expressed as the share directed to j of the total outflows of i. The attractiveness term (of the destination country) is proxied by a set of variables such as: banking secrecy, government attitude, swift membership, conflicts and corruption. The two latter right-hand side controls are multiplied by fixed parameters set by the author by means of an "inspirational guess". As for the distance, Unger (2009) proxied it with "cultural factors", namely, sharing a common language, having colonial ties or being major trading partners. She also included in the attractiveness term a dummy indicating membership to the Egmont Group (a cooperative organization of Financial Intelligence Units) and the size of Financial Sector (measured as the amount of deposits). Unfortunately there is no economic theory underlying the above empirical correlations[3]. Moreover, the authors apply the gravity equation to an estimation of money laundering flows, obtained from an estimation of criminal revenues which are inherently measured with error.[4]

A workable attempt to overcome this last issue has been taken by Ferwerda (2012) who concentrated on Trade Based Money Laundering (TBML). It refers to criminal proceeds that are transferred around the world using fake invoices that undervalue - or overvalue - imports and exports. He thus applies a traditional gravity equation to a dataset of TBML flows from U.S. to the rest of the world (Zdanowicz, 2009) and finds that the traditional gravity model for trade can explain TBML flows worldwide in a plausible manner, and suggests that criminals may use TBML in order to escape the stricter anti-money laundering regulations of financial markets.

Finally, to conclude this brief review, there are three works that merge the empirical literature on financial gravity models and that on "dirty" money flows which are particularly relevant to the research we undertake. The first, "Offshore Financial Centres: parasites or symbionts?" (Rose and Spiegel, 2007), investigates the determinants of cross-border asset holdings for 2001-2002 with a gravity model, making use of data from the Coordinated Portfolio Investment Survey of IMF. An

[3]e.g. there is no economic theory stating that Bank Secrecy counts three times more than Swift Membership in the decision-making process of the criminal organization that must allocate its funds, as stated in the Walker-Unger models

[4]Walker (1994) estimated the proceeds of crime in Australia and the proportion of those proceeds that are likely to be laundered. He estimated the extent of recorded and unrecorded crime, and took only the property loss components of the costs as being equal to the proceeds of crime (Unger, 2009). Depending on the crime type, proceeds were discounted. Since no actual data could measure the extent of laundering, Walker conducted an expert survey to determine the proportions of proceeds likely to be laundered. The estimates produced by the model are therefore tested on other estimates and this fact may make their reliability questionable.

interesting aspect of this work is that it shows how - maintaining a conceptual difference between Tax Havens and Money Launderers - this kind of country attracts more assets than expected and is more likely to be an OFC. The second work is by Cassetta et al. (2014). Using data from UIF's S.Ar.A archive and considering Italian cross-border bank transfers from 2007 to 2010, the authors investigate through a gravity model how much of the flows of capital from Italy are not explained by the main economic and socio-demographic characteristics of source and destination countries, and what other factors are relevant. Using the residuals from the main econometric specification, they construct an index of anomaly, finding a positive and statistically significant correlation between the index and the rate of crime in the province of origin of the funds and between the index and foreign jurisdictions' opacity of legislation. Finally, Haberly and Wójcick (2014) study foreign direct investments (FDI) to offshore financial centers. The authors assess determinants of tax haven FDI stocks in non-tax havens ("offshore FDI") in relation to FDI stocks among non-tax havens ("real FDI"). This is to our knowledge the first work comparing investments in offshore and non-offshore territories to assess if and how their determinants impact differently. They find that offshore FDI are as sensitive to physical distance as real FDI. Moreover, offshore FDI links are particularly strong between colonial powers and their current and former colonies, contrary to their non-offshore counterparts. Both real and offshore FDI are routed along zero withholding tax pathways and a wide third-country "treaty shopping" practice is also evidenced.

3 Empirical strategy and identification

Although we agree that gravity models are a workable tool for investigating "dirty" money flows - allowing characteristics of both source and destination countries to be taken into account - we believe that the use of "‘ad hoc"’ empirical equations that lack strong theoretical economic foundations should be avoided. Our identification strategy to assess "dirty" money flows at the global level is thus to estimate a well specified theoretical based gravity model of financial flows and then look at the differences between the predicted and the actual flows. This provides robust empirical evidence on which places attract more funds than expected and from where (i.e. which bilateral flows present higher anomalies measured as studetized residuals).

To this end, we first apply the theoretical framework provided by Okawa and van Wincoop (2012) to estimate the potential gravity financial flows on the basis of the theory of portfolio investment flows. In this framework, bilateral financial flows are positively driven by a size factor, that is the total equity holdings of destination and supply of equity of origin countries divided by world demand (supply) - and negatively affected by relative frictions. Those frictions act as multilateral resistances in the literature on trade flows and have the same scope and structure as in gravity models for trade (see Anderson and Van Wincoop, 2003). However, while in trade gravity they are modeled as *trade obstacles* (relative prices), in a financial gravity setting they should be conceived as *asymmetric information*. Starting from the theoretical framework provided by Okawa and an Wincoop (2012) (see Appendix 2 for additional details), it is possible to derive a gravity equation of financial flows in the form of:

$$X_{ij} = \frac{S_i E_j}{E} \frac{\Pi_i P_j}{\tau_{ij}} \tag{1}$$

where X_{ij} represents financial flows from country i to country j. $\frac{S_i E_j}{E}$ is a size factor composed by the ratio of equity supply in country i (S_i) times equity demand in country j (E_j) on world demand of equity (E). τ_{ij} represents bilateral frictions, so $\frac{\Pi_i P_j}{\tau_{ij}}$ is a relative friction, where Π_i and P_j are multilateral resistance variables that measure the average financial frictions faced by countries i and j respectively.

By log-linearizing Equation 3.2, Okawa and Van Wincoop (2012) get the following empirical equation:

$$ln(X_{ij}) = -\sum_{m=1}^{M} \phi_m z_{ijt}^m + \eta_{it} + \xi_{jt} + \epsilon_{ijt} \tag{2}$$

where they assume $ln(\tau_{ij}) = \sum_{m=1}^{M} \phi_m z_{ijt}^m$, that is financial frictions are related to a set of M observables. It is worth stressing that in this setting z_{ijt}^m must be thought of as a set of factors affecting information frictions and that, in our empirical analysis, $ln(S_i) + ln(\Pi_i/E)$ and $ln(E_j) +$

$ln(P_j)$ are substituted with country/counterpart-time specific dummies $\eta_{it} + \xi_{jt}$ (Okawa and Van Wincoop, 2012).

In the second step of our study, following Cassetta et al. (2014), we assume that the analysis of the error term of the above estimated gravity model can reveal patterns of anomaly in international portfolio investment flows which could be correlated with measures of illicit activity. To this end, we perform an analysis of the residuals of the estimated gravity model to reveal anomalies in international portfolio investment flows and then correlate these "anomalies" (i.e. the studentized residual) to financial secrecy and other variables the related literature considers facilitating "dirty" money flows.

To assume that the error terms of Equation 2 may be correlated with anomalous investments (eventually linkable with illicit activities), we should clean ϵ_{ijt} as much as possible of other sources of heterogeneity. To this end, in the first step, we estimate the model by using different estimation techniques (LSDV and PPML) adding a full set of fixed effects (country-time, counterpart-time and pair fixed effects). These absorb all the traditional gravity variables, with country-time and counterpart-time fixed effects capturing time-variant characteristics of origin and destination countries and pair fixed effects capturing both distance and bilateral linkages proxying time-invariant bilateral financial frictions and also preventing reverse causality (Head and Mayer, 2014). Furthermore, to control for possible residual heteroskedasticity bias in the data, we employ robust errors clustered over country pairs.

We are aware that the above residuals do not include only "dirty" money but also other kinds of heterogeneity and, on the other hand, that some of the "dirty" money flows may be captured by the fixed effects included in the estimates. However, our aim is not to assess the exact magnitude of illicit or sub-legal flows from one country to another, rather to associate probabilities between those anomalous flows and the most common risk factors highlighted by the dirty money and financial secrecy literature. If we prove that the probability of observing an anomalous flow (i.e. a high residual) is positively and significantly related to risk factors related to dirty money flows, we could use these anomalies as robust proxies to map the dyadic risk of observing illicit financial activities between each country pair. This global map of risk could be seen as a preliminary tool for a wider range of activities in preventing money laundering, tax evasion, capital flight and other phenomena that compose the illicit or sub-legal part of global financial flows.

4 Data and descriptive statistics

Since we are interested in assessing the global patterns of dirty money flows, the dependent variable of our gravity estimation is the total bilateral international portfolio holdings. The data source is the Coordinated Portfolio Investment Survey (CPIS) of the IMF for the year 2001- 2015. The purpose of the survey is to collect information on the stock of cross-border holdings of equities, investment funds shares, long-term debt securities, and short-term debt securities, valued at market prices and broken down by the economy of residence of the issuer (Central bank reserve holdings are excluded). For each participating economy, the CPIS reports holdings in all destination economies.

The definition of portfolio investment used in CPIS is any cross border transaction and position involving debt or equity securities, excluding those included in direct investment or reserve assets (as defined in the Balance of Payments and International Investment Position Manual, sixth edition (BPM6)). For the purpose of our gravity analysis, we create an unbalanced panel merging CPIS data with CEPII gravity dataset[5].

We acknowledge some well known problems with CPIS data, e.g.: i) incomplete country coverage as a possible source of self-selection bias; ii) possible under-reporting of assets by CPIS participants due to in-complete institutional coverage; iii) third party holding since the survey responses in some countries may be based on custodians. We believe that these elements do not affect our analysis. As for the "sample selection bias", since major asset holders participate regularly in the survey and since the share of portfolio investment activities of non-participants is negligible, we believe that it is not a major issue in this case. Indeed, we have a sample of 85 origin and 214 destination

[5]CEPII makes available a gravity dataset for all world pairs of countries, for the period 1948 to 2015, allowing the estimation of international flows as a function of GDP, population and trade costs. The main variables relating to trade costs come from the CEPII distance dataset (GeoDist). GDP and populations come mainly from the World Bank Development Indicators (WDI).

countries (See tables 8 and 9 in the Appendix 1 for the full list), including 21 origin OFCs and 32 destination OFCs (Table 11, Appendix 1). Possible under-reporting of assets is controlled for by variables proxying for institutional and data collection quality, such as per capita GDP or country-time and counterpart-time fixed effects. The problem of third-party holding is not a source of bias for our analysis, as considering the real, final destination of financial flows is not fundamental to pursue our research objectives. Actually, we are not interested in the ownership of assets held in a country, rather in assessing how funds may move from one country to another to check whether some locations attract more portfolio investments than expected and whether this relates to secrecy differentials which are known to be exploitable to hide the true ownership of an asset (see, among others, Christensen, 2012; Cobham et al., 2015; Ledyaeva et al., 2015).

In Figure 2 (Appendix 1) we report a geographical break-down of financial flows in our sample. We can see how most of the investments' value comes from Europe and the Americas and is directed towards the same two regions, where are located not only most of the OFCs in our sample, but also many very important financial centers. In fact, in Figure 3 (Appendix 1) we report the number of operations directed to OFCs, divided by region, and we show that most of them are directed to OFCs located in the Americas and in Europe, strongly resembling the distribution of total investment. In Figure 4 (Appendix 1), we show that the proportion of flows to OFCs compared with flows to non-OFCs for the whole sample is actually not negligible.

As part of the preliminary explorative analysis of our data, we plotted the growth rate of investment flows splitting the sample into Offshore and non-Offshore countries (Figure 5, Appendix 1). We can see that portfolio investment flows to OFCs climbed over flows directed to other countries following the last global financial crisis. This confirms that no matter the measures implemented to target OFCs - and in particular the advantages they offered in terms of low-taxation-schemes and secrecy regulations - after the crisis, offshore places remained very attractive to international capital. However, a rigorous distinction should be done between "secrecy" and "offshoreness". If it is true that Offshore Financial Centers have on average a higher degree of financial secrecy, compared to non-OFCs (see Figure 6, Appendix 1), onshore secrecy is a very important and under-looked component in the studies on dirty money flows. Very "large" onshore countries, such as the United

States, appear in fact to have a very high ranking in the Financial Secrecy Index (FSI henceforth), making it clear that there exist a very relevant non-offshore secrecy dimension that must be taken into account. Dirty money may be directed not only to small remote islands but also to big financial centers where they can exploit a certain level of secrecy as well. The fact that OFCs have in general an high degree of secrecy could be interpreted as a "resilience" tool to the regulatory targeting they have been subject to and/or as a lasting comparative advantage for those small countries and territories to accommodate the need of "secrecy spaces" of financial capital flows, in particular because of their greater difficulties in finding other paths to economic growth[6]. On the other hand, onshore secrecy may be interpreted as stemming from the freedom that more influent big financial centers have in establishing global rules and then not fully following them. For these reasons, in this study the issues of "offshoreness" and "secrecy" will be discussed separately and analytically. Table 12 (Appendix 1) reports a description of the main explanatory variables used in our empirical analysis, namely: total investment in assets denominated in US Dollars, GDP per capita of source and destination countries, Secrecy Score (SS) of destination countries and Corruption Perception Index (CPI) of source and destination countries [7], OFC dummies, EGMONT membership dummies and geographical distance.

5 Empirical analysis

Our empirical analysis adopts a two-step strategy. First, we derive the value of the coefficients able to predict portfolio flows on the basis of Okawa and van Wincoop (2013)'s gravity framework. Second, we perform an analysis of the residuals of the estimated gravity model to reveal patterns of anomaly in the international portfolio investment flows and their correlation with financial secrecy and other variables considered by the related literature to facilitate "dirty" money flows. To assume

[6]Financial secrecy may be used - in other words - to alleviate the "remoteness" condition of a Small Island Territory, even supporting reputational costs (See Hampton and Christensen, 2002; 2007).

[7]We recall that CPI's data points are expressed on a scale of 0- 100 where a 0 represents the highest level of perceived corruption, and 100 the lowest level of perceived corruption. Hence, in the empirical analysis a lower coefficient will indicate and higher impact of corruption.

that the error terms in Equation 2 may be correlated with anomalous investments (eventually linkable with illicit activities), we should clean ϵ_{ijt} as much as possible of unobservables. To this end, in the first step, we estimate the model by using different techniques (LSDV and PPML) with a full set of fixed effects (origin-time, destination-time and pair fixed effects) proxying for multilateral resistances. The PPML specification allows to increase robustness and unbiasedness also for financial flows, as suggested by Santos Silva and Teneyro (2016).[8] Furthermore, to control for possible further heteroskedasticity in the data, we employ robust errors clustered over country pairs in all the specifications.

5.1 Assessing potential financial flows

We first estimate expected portfolio investment flows with the full set of "traditional" gravity independent variables with per capita GDPs to control for country dimension (column 1 Table 1). Then, we gradually add origin-time, destination-time and pair fixed effects. In column 2, we report the estimation results obtained by LSDV, which includes origin-time and destination-time FE to control for the multilateral resistance terms as suggested by the literature (Okawa and Van Wincoop, 2013). In column 3 the same model is estimated with the PPML estimator advised by Santos Silva and Tenreyro (2006) [9] Finally, Columns 4 and 5 contain the estimation of the model respectively by LSDV and PPML, augmented with the full set of FE (pair FE, origin-time and destination-time FE). We use this final estimates to obtain the cleanest possible residual to be used in our second-step analysis.

In general, all coefficients in Table 1 show the expected significance and signs, with GDPs

[8]Santos Silva and Tenreyro(2006) highlight that Jensen's inequality has been neglected in several econometric applications and that one important implication of the latter is indeed that the practice of interpreting the parameters of log-linearized models estimated by OLS as elasticities can be highly misleading in presence of heteroskedasticity. This is the reason why they propose a pseudo-maximum-likelihood estimator which also provides a way to deal with zero values of the dependent variable.

[9]For the PPML estimation, we used the stata command *ppml_panel_sg* (Larch et al, 2017), which enables faster computation of the many fixed effects required for panel PPML structural gravity estimation. In particular, it addresses the large number of pair fixed effects we need, also simultaneously absorbing the origin-time and destination-time fixed effects implied by theory.

Table 1: Gravity Model estimation

VARIABLES	(1) OLS	(2) LSDV without pair FE	(3) PPML without pair FE	(4) Full FE LSDV	(5) Full FE PPML
Origin GDP	1.471***				
	(0.0358)				
Destination GDP	0.960***				
	(0.0271)				
Distance	-0.418***	-1.133***	-0.383***		
	(0.0394)	(0.0326)	(0.0418)		
Common colony	-0.510***	0.791***	1.210***		
	(0.177)	(0.132)	(0.354)		
Common language	1.192***	0.553***	0.226*		
	(0.118)	(0.0836)	(0.123)		
Common religion	-0.0561	0.994***	0.245		
	(0.139)	(0.110)	(0.199)		
Common legal system	0.00687	0.0262	0.0806		
	(0.0859)	(0.0534)	(0.0988)		
Common currency	2.355***	0.581***	0.939***	0.673***	0.335
	(0.155)	(0.111)	(0.120)	(0.160)	(0.253)
Constant	-2.736***	26.86***		17.63***	
	(0.610)	(0.287)		(0.00808)	
Observations	61,135	65,004	127,047	64,962	87,828
R-squared	0.330	0.738	0.891	0.905	0.989
Multilat.Res.FE	no	yes	yes	yes	yes
Pair FE	no	no	no	yes	yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

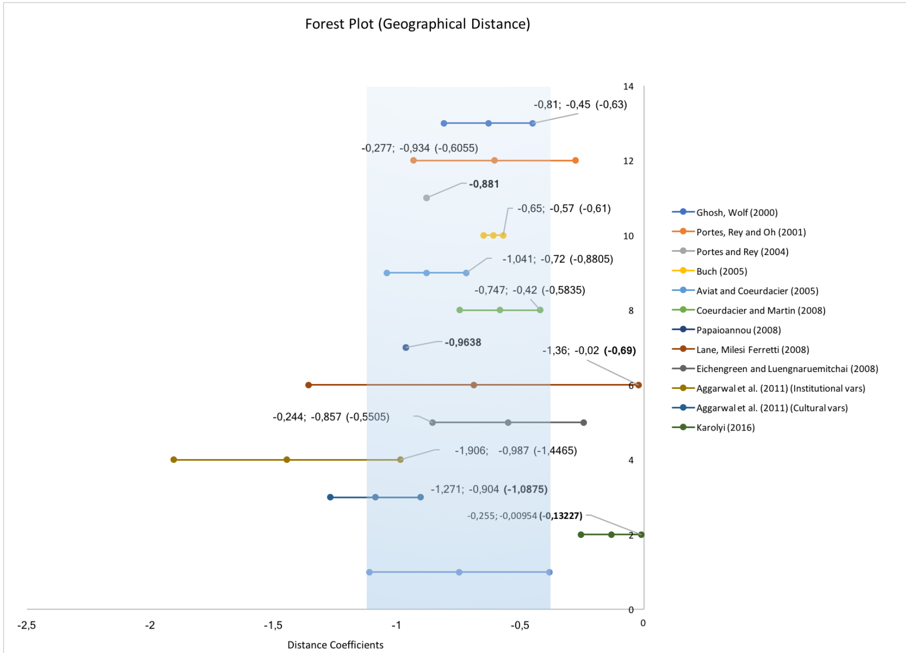
proxying for country dimension showing a positive and significant impact on bilateral portfolio investments and distance showing a negative and significant coefficient. Also, a shared colonial past appears to have a positive and significant impact as well as common language and common currency. Column 2 shows that LSDV estimates provide upward-biased parameters for distance compared to PPML, consistently with our expectations.[10] Furthermore, using PPML we manage to get a very high R-squared (0.989). Plotting fitted versus real values of our dependent variable, Figure 7 in Appendix 1 clearly shows that the goodness of fit of PPML is superior to that of its LSDV counterpart. Since we are looking for a residual that is the cleanest possible, we opt for the PPML specification with the full set of origin-time, destination-time and pair fixed effects to derive the anomalous flows to be used in the subsequent analysis[11].

To show that our results are consistent with previous literature we report in Figure 1 a forest plot showing upper and lower estimates of distance reported in all the papers included in our literature review. We use distance because it is the only variable that is present in all the reported studies. The shaded column in 1 indicates the upper and lower coefficients on distance obtained by our empirical estimates, using traditional country pairs gravity variables together with origin-time and destination-time fixed effects to control for multilateral resistance terms (Columns 2 and 3 Table 1). Figure 1 shows that our results are in line with those obtained by other scholars (see also Table 7 in the Appendix).

[10]Due to short positions in securities, usually resulting from the sale of securities acquired under repurchase agreements, our dependent variable also shows negative values (specifically, we have 76,317 negative observations over a total of 272,850 observations). Since in a PPML setting there cannot be negative values in the dependent variable (Santos Silva and Tenreyro, 2006), in this exercise we took the absolute value of the dependent variable. Please note that we have also estimated the gravity model by OLS with all three versions of the dataset (original, without observations having negative values in the dependent variable and with dependent value transformed in its absolute value) and we have observed no substantial change in the coefficients (test regressions are available upon request).

[11]We will use the full FE PPML specification for the main analysis and the LSDV specification to test for the robustness of our results in Section 6.

Figure 1: **Forest plot of coefficients of distance**



5.2 Residual ranking and analysis

Following Cassetta et al. (2014), we first construct an anomaly index from studentized residuals (i.e., divided by their standard deviation), normalizing them on a 0-1 scale. Table 14 in Appendix 1 provides the rank of the first 50 "anomalous observations" in our dataset, assigning rank 1 to the country pair that registered the most anomalous portfolio investment annual flow over the investigated period. At a first glance, it highlights a clear pattern of anomaly that involves high-GDP countries - especially those hosting major financial centers - as "anomalous origins" and OFCs as "anomalous destinations".

We should now investigate whether the most anomalous flows are correlated with the standard covariates used by the literature on illicit money flows. In particular, we control for the variables used by Walker and Unger (2009), namely Egmont membership[12] and Corruption Perception Index

[12] EGMONT group is an informal network of Financial Intelligence Units that work on stimulating international cooperation to hamper the proliferation of money laundering and terrorism financing networks.

(CPI) as well as financial secrecy and offshore status (as in Cassetta et. al (2014) and Leyaeva et al. (2015) among others). To control for financial secrecy, we use the Secrecy Score (SS). [13] According to Tax Justice Network (TJN). SS is calculated for a selected list of countries known to provide favorable conditions to disguise and hide money. Hence, we assign SS score equals to 0for all the countries in our dataset not included in the FSI one. We also include a corporate tax level variable (TAX) in some specifications. This is because financial secrecy tends to be very highly correlated with tax havenry, with the difference that low taxes attract all kinds of monies, while financial secrecy relates more directly with illicit flows *per se*. We will verify whether countries with high secrecy still have anomalously strong connections to origin countries, even when controlling for taxation. Since SS data are not available annually, in the subsequent estimates we use the mean of previous and following year's SS value to fill the gaps[14]. We then construct an "anomaly level" variable that categorizes the previously calculated studentized residuals assigning score 1 if the

[13] The SS from Tax Justice Network is the unweighted version of the Financial Secrecy Index. The latter is composed by the Secrecy Score weighted by the Global Scale Weight (GSW) of the respective jurisdiction. The GSW is built using the same CPIS portfolio holdings data we use as dependent variable in our first-step analysis, from which we get the residuals that we use as dependent variable in the second step. Therefore, using the weighted index would create a circular-logic problem in the anomalies' analysis. The FSI is published by Tax Justice Network (TJN) every other year since 2009. The Financial Secrecy Index (FSI) and the respective SS is calculated for a selected list of countries known to provide favorable conditions to disguise and hide money. In the first FSI project in 2009 TJN consulted eleven different lists of tax havens compiled by international institutions (such as the IMF, OECD, or Financial Action Task Force) to draw up a list of 60 secrecy jurisdictions. In 2011, 13 new jurisdictions were added to the previous list, based on two criteria. Four jurisdictions - Botswana, Ghana, Guatemala and San Marino - were found to be offering secrecy facilities even though they were not included in the previous list of 60. Nine others had large financial centres, therefore presented higher vulnerability regarding the transit of dirty money. These were Canada, Denmark, France, Germany, India, Italy, Japan, Korea, and Spain. In 2013, 9 additional jurisdictions were added, two of which were chosen based on indications that secrecy services are offered (Dominican Republic and New Zealand), and seven were added based on their scale of financial services exports (Australia, Norway, Brazil, Sweden, Russia, Saudi Arabia and South Africa). In 2015, six countries were added because of their share in the global market of offshore financial services was in the Top 40. Seven countries were added because of indications of secrecy or financial centre ambitions (Bolivia, Chile, Gambia, Macedonia, Montenegro, Paraguay, Tanzania). In addition to this, for the FSI 2015 all OECD members have been added following various publications about the role these countries play in absorbing and facilitating illicit financial flows (Czech Republic, Estonia, Greece, Iceland, Poland, Slovakia, Slovenia).

[14] We have also repeated the estimation both using available years only and using the previous year's SS value to fill the gaps, without noticeable changes. Results are available upon request

studentized residual is less than 2, score 2 if the studentized residual is between 2 and 3 and score 3 if it is equal to 3 or higher.[15] We use this anomaly variable as dependent variable in a ordered probit estimation to test weather our coefficients may vary depending on the "anomaly region" the observation belongs to. Ordered probit estimates are reported in Table 16 in the Appendix. As expected, both cut points for our three established intervals are highly significant, highlighting the presence of heterogeneity in the relationship between our set of dirty-money related covariates and the anomaly level of country-pairs as a function of the anomaly region the country pair is in. An apparently puzzling outcome of this preliminary evidence is the fact that the tax level of the destination is always positive significant. This result is actually in line with the previous empirical literature on money laundering showing that "criminals pay taxes". In other words, if tax evasion and tax avoidance are predicate offences for money laundering (i.e. profits from tax evasion need to be laundered somehow) this does not mean that one of the characteristics of the destination jurisdiction is low taxation. In practice, all else being equal, a destination offering more secrecy and less controls is usually preferred to one with lower taxes. This because in the case of illicit funds what matters is not avoiding taxes but not being caught moving ill gotten capital around. Once tested for the presence of an heterogeneous relationship between our covariates and the probability of an observation to be classified as an outlier, Tab. 5.2 presents a further probit exercise to look explicitly at the specific relationship of the same set of covariates on the probability of an observation to overcome our anomaly threshold (i.e., showing a value of studentized residuals higher than 2). To this end, we use here two alternative dependent dummy variables, $OutHigh$ and $OutLow$ indicating, respectively, weather the "‘anomalous observation is classified as an outlier according to one or the other threshold (less or higher than 3).

In both column 1 and column 8 of Table 5.2, hence both using low-threshold and high-threshold dependent variables, secrecy of the destination has a positive and significant effect on the probability of a given country-pair to register an anomalous amount of flows, while secrecy of the origin shows a negative sign, meaning that anomalous pairs are most likely to be composed by a less-secret origin

[15] We recall that 2 and 3 are the values of studentized residuals past which an observation is commonly considered an outlier by the specialized literature.

Table 2: Probit estimation with low and high "‘anomaly thresholds"’

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
VARIABLES	OutLow	OutLow	OutLow	OutLow	OutLow	OutLow	OutLow	OutHigh	OutHigh	OutHigh	OutHigh	OutHigh	OutHigh	OutHigh
$CPI(o)$			-0.000937	-0.000955	-0.000945	-0.000932	-0.000937			-0.00297***	-0.00299***	-0.00298***	-0.00297***	-0.00298***
			(0.000635)	(0.000783)	(0.000689)	(0.000775)	(0.000812)			(0.000580)	(0.000715)	(0.000718)	(0.000674)	(0.000803)
$SS(o)$	-0.00289***	-0.00371***						-0.00343***	-0.00462***					
	(0.000310)	(0.000487)						(0.000344)	(0.000433)					
$SS(d)$	0.000818**	0.00304***	0.00173***		0.000846*	0.00194***	0.000798**	0.000594*	0.00284***	0.00122***		0.000254	0.000973*	0.000241
	(0.000321)	(0.000402)	(0.000396)		(0.000440)	(0.000621)	(0.000403)	(0.000343)	(0.000443)	(0.000444)		(0.000592)	(0.000551)	(0.000524)
$OFC(d)$				0.217***	0.194***	0.290***	0.187***				0.215***	0.208***	0.267***	0.206***
				(0.0304)	(0.0344)	(0.0513)	(0.0423)				(0.0390)	(0.0413)	(0.0578)	(0.0340)
$OFC(d) = 1 * SS(d)$						-0.00304***							-0.00192**	
						(0.00106)							(0.000901)	
$TAX(o)$		0.00164*	0.00176	0.00172	0.00175*	0.00177	0.00175		-0.000918	0.000269	0.000262	0.000271	0.000282	0.000271
		(0.000874)	(0.00110)	(0.00124)	(0.00104)	(0.00125)	(0.00128)		(0.000901)	(0.00131)	(0.00136)	(0.00126)	(0.00125)	(0.00136)
$TAX(d)$		0.00507***	0.00494***	0.00553***	0.00552***	0.00538***	0.00533***		0.00199	0.00188**	0.00248**	0.00248**	0.00240***	0.00243**
		(0.00108)	(0.00109)	(0.00113)	(0.000913)	(0.000960)	(0.00109)		(0.00126)	(0.000955)	(0.00112)	(0.00103)	(0.000902)	(0.00101)
$EGMONT(d)$							0.0465							0.0123
							(0.0381)							(0.0442)
Constant	-1.792***	-2.090***	-2.044***	-2.070***	-2.084***	-2.098***	-2.116***	-1.816***	-1.955***	-1.836***	-1.875***	-1.879***	-1.888***	-1.887***
	(0.0101)	(0.0593)	(0.0683)	(0.0765)	(0.0495)	(0.0739)	(0.0760)	(0.0115)	(0.0528)	(0.0599)	(0.0664)	(0.0648)	(0.0684)	(0.0703)
Observations	72,433	33,606	29,580	29,580	29,580	29,580	29,580	72,433	33,606	29,580	29,580	29,580	29,580	29,580

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

investing in a secrecy jurisdiction. The effect is confirmed also correcting for tax levels (colums 2 and 9), for both dependent variables. Here, as in the previous preliminary ordered probit estimation, tax levels of the destination country show a positive sign, confirming that the anomaly in portfolio investments is determined by the secrecy offered by a jurisdiction rather than by the possibility of exploiting a low-tax regime (i.e. "dirty money" are directed more to secrecy jurisdictions than to tax havens). This means that all else equal, anomalous flows tend to be directed towards jurisdictions that are more secret rather than having a low tax level. Corruption perception of the origin country seems to have a statistically insignificant effect for the lower-threshold dependent variable (column 3) and a negative significant impact for the higher (i.e. more restrictive) threshold of the dependent variable (column 10). Low significance of corruption for dirty money flows for the lower threshold has been confirmed by other studies (see Haberly, 2019 for FDI). However, recalling that the CPI gives a lower score to the most corrupt countries, the negative coefficient at the origins for the most anomalous observations (having a studentized residuals higher than 3) indicates that home country corruption is a driver of anomalous flows as corruption proceeds also need to be laundered (See also Ledyaeva et al., 2015). In columns 4 and 11 we substitute secrecy variables with offshore status dummies, obtaining as expected positive significant coefficients that confirm the offshore status of a jurisdiction is also an important pull factor for dirty money flows. Therefore, In columns 5 and 12 we try to include both secrecy and the offshoreness dummy in the regression. For the lower-threshold dependent variable we obtain positive significant coefficients for both, meaning that, all else being equal, a destination which is an offshore financial center **and/or** has an high level of financial secrecy is more likely to appear in an anomalous country-pair, being destination of illicit financial flows. However, using the more restrictive threshold the secrecy coefficient looses its statistical significance. In columns 6 and 13, we interact secrecy and offshore dummies to control for the possibility of a different effect of secrecy level in offshore financial centers and "onshore" jurisdictions. We find that the interaction of the two variables has a negative significant impact for both thresholds of the dependent variable, meaning that onshore secrecy is preferred to offshore secrecy. This is not surprising, as being categorized as an offshore jurisdiction implies - in many cases - a negative reputation for that jurisdiction. Therefore, in order not to raise any suspect when moving dirty money through financial channels, a secret but onshore jurisdiction may be preferred to an offshore financial center. This is a key take home argument: sound empirical analysis on dirty money flows should not strictly rely on an rigid institutional approach (e.g., looking only at countries classified as OFCs) rather contributing to depict an holistic framework about the main determinants of financial flows able to detect anomalies that, in turn, could also be assumed as a function of a change in institutional settings and policies, drawing a line between formal and substantial cooperation to the international fight against dirty money flows. To this end, to provide a further test on the role of institutions and international cooperation. In columns 7 and 14 we add in the regression a dummy for Egmont membership. This proxies for the participation of the Financial Intelligence Unit of the destination country in the global AML efforts. As expected, also this coefficient is not statistically significant for both dependent variables. In fact, many countries showing a very high secrecy score have an operational FIU that is part of the EGMONT group, but still keep their secrecy and compliance levels low under all other aspects.

6 Sensitivity Analysis

In this section we perform some robustness checks on the second-step of our analysis, i.e. on the assessment through probit analysis of the associated probabilities of variables related with "dirty" money and anomalies in the global financial flows' distribution.

First, we test the main dependent variable of our second-step estimation, i.e. financial secrecy. Since the financial secrecy index has been calculated using different indicators/criteria for every year, we here repeat our estimates by using the relative value of secrecy for each jurisdiction. This means including in the regression a variable that does not aim to represent the overall level of secrecy of the considered jurisdiction, rather helps to provide sound insights about the relative measure of secrecy for each country in the sample. This latter variable corrects for the potential bias due to any kind of inconsistencies and/or not coavariate measurement errors included in the financial secrecy score. This second set of results using the dummy OutLow as dependent variable strongly resembles those of the main specification used in this paper, hence confirming the robustness of the results (see Table 3).

A second test is on the dependent variable of the second step of our analysis (i.e. the studentized residual of the PPML estimated gravity model), first we estimate a simple gravity equation only including GDPs to proxy for countries' dimension and physical distance to control for informational frictions. Our aim here is to demonstrate that our findings are robust no matter the specific theoretical assumptions in the Okawa and VanWincoop's (2013) Gravity model. As Table 4 shows, the ranking of the top-20 anomalies of the distribution stay pretty much the same, confirming the validity of previous findings.

Finally, the last robustness check is motivated by the concern that the pairs resulting as outliers after the gravity model estimation may have some hidden characteristics that would make them appear anomalous with any kind of flow, or that the anomalies that we have found could be due to other factors impacting on the size of the portfolio investments, such as trade flows between the same two territories or direct investments between the two countries. In fact there appear to be very peculiar countries, with huge financial sectors, high GDPs but very small size, together

Table 3: Probit estimation with relative secrecy score

VARIABLES	(1) OutLow	(2) OutLow	(3) OutLow	(4) OutLow	(5) OutLow
$SS(o)_{rel}$	466.6	-2,690			
	(2,998)	(3,108)			
$SS(d)_{rel}$	-338.3	2,240	351.6***	355.8***	338.2**
	(2,064)	(2,141)	(110.3)	(110.6)	(148.6)
$OFC(d)$				0.280***	0.271***
				(0.0504)	(0.0429)
$OFC(d) = 1 * SS(d)_{rel}$				-629.2***	-609.3***
				(217.3)	(220.3)
$TAX(o)$		0.00158*	0.00176*	0.00176	0.00175
		(0.000894)	(0.00105)	(0.00118)	(0.00114)
$TAX(d)$		0.00482***	0.00492***	0.00541***	0.00524***
		(0.000933)	(0.000974)	(0.00109)	(0.000906)
$CPI(o)$			-0.000962	-0.000950	-0.000942
			(0.000619)	(0.000668)	(0.000701)
$EGMONT(d)$					0.0415
					(0.0391)
Constant	-1.831***	-2.118***	-2.034***	-2.088***	-2.116***
	(0.0100)	(0.0444)	(0.0518)	(0.0711)	(0.0626)
Observations	72,433	33,606	29,580	29,580	29,580

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Top 20 outliers from simpler GDPs-Distance gravity model

Rank	**Country**	**Counterpart**	**Year**
1	United States	Cayman Islands	2014
2	United States	Cayman Islands	2015
3	United States	Ireland	2015
4	United States	Cayman Islands	2012
5	United States	Cayman Islands	2013
6	Luxembourg	United States	2014
7	United States	Cayman Islands	2011
8	United States	Ireland	2014
9	United Kingdom	Germany	2014
10	United Kingdom	United States	2008
11	United Kingdom	Germany	2015
12	France	Luxembourg	2015
13	Luxembourg	United States	2013
14	Germany	Luxembourg	2008
15	United Kingdom	United States	2009
16	United States	United Kingdom	2003
17	United Kingdom	Germany	2012
18	Japan	Cayman Islands	2010
19	United States	France	2007
20	United Kingdom	United States	2010

with territories that even if independent are part of the Commonwealth or are partially politically dependent from other territories. To show that this is not the case and that the anomalies we have found are specific to portfolio investment transactions, we conducted a Spearman test on the anomaly index we constructed. To this end, we estimated two more gravity equations with the same full-fixed effects PPML specification employed for the identification of anomalies related to portfolio investments, but using as dependent variables Trade (total import flows from UN COMTRADE) and FDI flows (from the Coordinated Direct Investment Survey (CDIS), IMF)[16] instead. Then, as for the main analysis, we have computed studentized residuals from both the alternative specifications, produced two anomaly index relative to foreign direct investments and trade flows with the same ranking criterion as in the main analysis and finally tested if the ranking from the main specification was correlated with these other two with a Spearman's rank correlation test. A perfect Spearman correlation of $+1$ or -1 means that each of the tested variables is a perfect monotone function of the other. The value of the test's coefficient would be high if the variables had a similar anomaly rank, and low in case of a dissimilar (opposed if the coefficient was -1) rank between the two variables. In our case, as shown in Table 6, the correlation coefficient is very low for both alternative dependent variables. This supports our identification strategy, confirming that the anomalies resulting from our first-step estimation are specific of portfolio investment flows but also maintaining that the same strategy could be further exploited and applied to other kinds of flows that may contain illicit transactions.

Table 6: Spearman test on Anomaly Indexes

	Portfolio Investments	**p-value**
Direct Investments	0.0180	0.0020
Imports	0.0126	0.0280

[16] Due to data availability for CDIS, we estimated the latter two gravity models only us-ing years 2008 - 2015. We considered residuals from the specification with portfolio investments for only those years as well.

7 Conclusions

We have estimated a gravity model of financial flows, as proposed by Okawa and Van Wincoop (2012), in order to study its residuals and assess patterns of anomaly that could be related to "dirty" money flows. Acknowledging that it is not advisable to try to identify "dirty" money flows directly we suggest focusing on anomalies in official statistics instead, also given the unavailability of reliable data on the actual direction and amount of money laundering activities.

After obtaining "clean" residuals from a robust estimation, augmented with country-time, counterpart-time and pair fixed effects to control for all possible sources of variability, we computed and ranked (internally) studentized residuals of the model and found that the most anomalous flows actually involve jurisdictions with a high degree of financial secrecy and offshore financial centers but that in general onshore secrecy is preferred to offshore secrecy. This may be due with the negative reputation coming with the categorization of a country as "offshore". This is a key empirical results since it confirms the need to overcome a simple institutional approach when looking at global dirty money flows. This outcome is also confirmed by the lack of significance of the EGMONT group membership underlining the difference between formal and substantial participation to global AML efforts. These stylized facts underline that the real problematic pull factor for anomalous financial flows is a low compliance on the various factors that build financial secrecy.

Our results indicate that financial secrecy surpassing a certain threshold together with other factors related to "dirty" money are capable of diverting actual financial flows with respect to the theoretical path. In line with the literature on money laundering and "dirty" money flows, this reinforces the belief that non-compliance with international transparency standards affects the probability of observing anomalous flows and that a high residual may indicate the presence of illicit flows. In other words, we can say that the countries that are less cooperative with the global effort to enhance transparency and an exchange of information in financial fields are also those that systematically register overabundant financial flows, since those are attracted to destinations with specific characteristics of opacity not accounted for by the traditional model and not captured by fixed effects. Possibly, there are also fixed propensities to illict transactions for each country pair (probably induced by historical and institutional settings). With our estimation technique we are not able to see the above, since they will be absorbed by fixed effects. However, there are also time variant push and pull factors for dirty transactions (probably related to short term relative policies) that can be instead isolated thanks to our identification strategy. Hence, we are providing sound and conservative estimates of the investigated phenomena of the dirty money push-pull factors.

This work is to our knowledge the first attempt to use a global dyadic gravity analysis of the global network of illicit flows, assuming that one should not only focus on destinations of "dirty" money" but on anomalous couples of countries. This is a very important and underinvestigated field of analysis.

The results of this study are oriented towards fostering theoretical underpinnings of gravity equations of "dirty" financial flows, avoiding the construction of *ad hoc* equations. We believe our approach is indeed consistent with the theory and that it could deliver a picture of global "dirty" money flows which is far more credible than that from previous empirical approaches, also making it possible to exploit the potential of official and public data. To this end, the full dataset of bilateral anomalies in portfolio investment flows resulting from our empirical work is made freely available for further research.

Our work also has several implications for policy makers. First, it confirms that anomalies in financial statistics may be a warning sign that "dirty" money flows are present. Second, it highlights that it would be appropriate to investigate anomalous "couples of countries" rather than focusing on single risky destinations. In fact, since distance and other social, geographical and economic characteristics matter in the distribution of asset flows at a global level, they also matter in the distribution of "dirty" money flows. This means that rather than relying on "black lists" of tax havens and Offshore Financial Centers, it would be more practical to consider financial secrecy as a matter of degree and consider how each country's regulation (and implementation of it) interacts with others rather than simply establishing a threshold of compliance below which a jurisdiction becomes "blacklisted" or "risky".

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8 Appendix 1

Table 7: Selected empirical studies

Paper	*Sample*	*Years*	*O.FE*	*D.FE*	*T.FE*	*Pair FE*	*Inter.FE*	*OLS*	*PPML*	*Oth.*
Ghosh, Wolf (2000)	7 origins	1990-1994						CS		
Portes, Rey and Oh (2001)	1 to 40	1988-1998			×					
Portes and Rey (2004)	16	1989-1996	×	×	×					
Buch (2005)	5 to 50	1983, 1999						CS		
Aviat and Coeurdacier (2005)	19 to 62	2001	×	×						
Coeurdacier and Martin (2008)	27 to 61	2001	×	×						
Papaioannou (2008)	19 to 50	1984-2002	×	×	×	×	O-T			
Lane, Milesi Ferretti (2008)	n/a	2001	×	×				CS		IV, Tobit
Aggarwal et al. (2011) pt.1	174 to 50	2001-2007						PA		
Aggarwal et al. (2011) pt.2	174 to 50	2001-2007						PA		
Karolyi (2016)	62	2001-2012	×	×	×			PA	×	
Eichengreen et al. (2008)	70	2001-2003		×		×				RE(D)

Figure 2: **Portfolio flows by region**

Figure 3: **Porfolio flows to OFCs by region of destination**

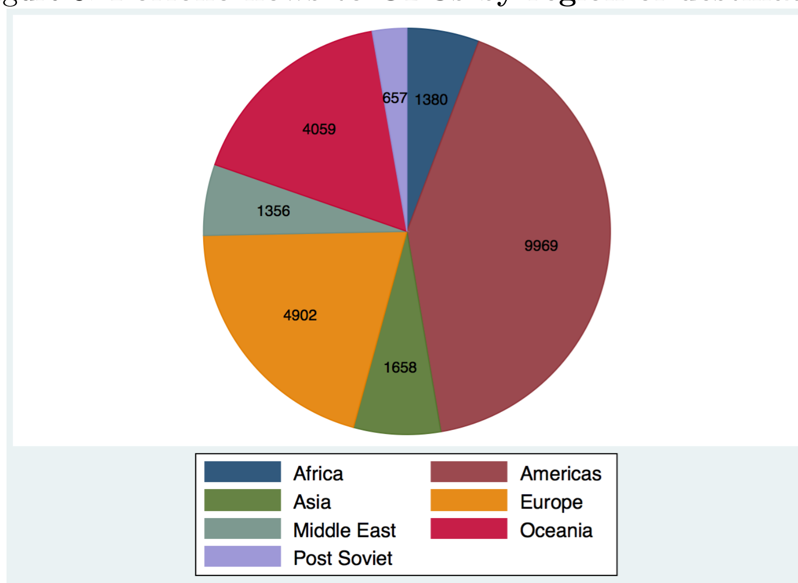

Figure 4: **Break-down of Portfolio Investment Flows**

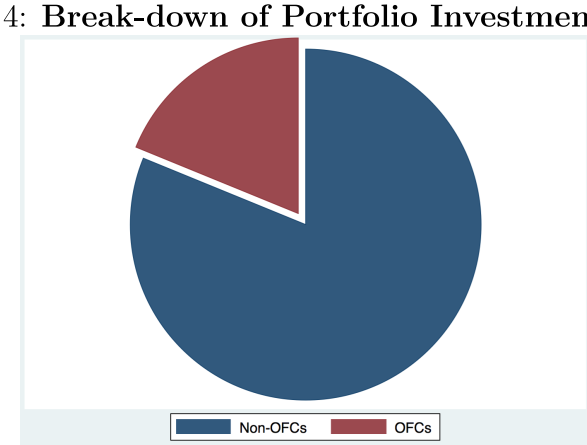

Table 8: Origin Countries

Albania	Greece	Panama
Argentina	Honduras	Peru
Aruba	Hong Kong	Philippines
Australia	Hungary	Poland
Austria	Iceland	Portugal
Bahamas	India	Romania
Bahrain	Indonesia	Russia
Bangladesh	Ireland	Saudi Arabia
Barbados	Israel	Singapore
Belarus	Italy	Slovak Republic
Belgium	Japan	Slovenia
Bermuda	Kazakhstan	South Africa
Bolivia	Kuwait	South Korea
Brazil	Latvia	Spain
Bulgaria	Lebanon	Sweden
Canada	Liberia	Switzerland
Cayman Islands	Lithuania	Thailand
Chile	Luxembourg	Turkey
China	Macao	Ukraine
Colombia	Malaysia	United Kingdom
Costa Rica	Malta	United States
Cyprus	Mauritius	Uruguay
Czech Republic	Mexico	Vanuatu
Denmark	Mongolia	Venezuela
Egypt	Netherlands	West Bank and Gaza
Estonia	Netherlands Antilles	
Finland	New Zealand	
France	Norway	
Germany	Pakistan	
Gibraltar	Palau	

Table 9: Destination Countries

Afghanistan	Chad	Gibraltar	Macao	Panama	Sweden
Albania	Chile	Greece	Macedonia	Papua N.G.	Switzerland
Algeria	China	Greenland	Madagascar	Paraguay	Syria
Andorra	Colombia	Grenada	Malawi	Peru	Taiwan
Angola	Comoros	Guadeloupe	Malaysia	Philippines	Tajikistan
Anguilla	Congo	Guatemala	Maldives	Poland	Tanzania
Antigua&Barb.	Cook Is.	Guinea	Mali	Portugal	Thailand
Argentina	Costa Rica	Guinea B.	Malta	Puerto Rico	Togo
Armenia	Cote d'Ivoire	Guyana	Marshall Is.	Qatar	Tonga
Aruba	Croatia	Haiti	Martinique	Reunion	Trinidad&Tob.
Australia	Cuba	Honduras	Mauritania	Romania	Tunisia
Austria	Cyprus	Hong Kong	Mauritius	Russia	Turkey
Azerbaijan	Czech Rep.	Hungary	Mexico	Rwanda	Turkmenistan
Bahamas	D.R.Congo	Iceland	Micronesia	S. Helena	Turks& C.Is.
Bahrain	Denmark	India	Moldova	S. Kitts&N.	Tuvalu
Bangladesh	Djibouti	Indonesia	Mongolia	S. Lucia	Uganda
Barbados	Dominica	Iran	Montserrat	S.Pierre&Miq.	Ukraine
Belarus	DominicanR.	Iraq	Morocco	S.Vincent&Gr.	UAE
Belgium	Ecuador	Ireland	Mozambique	Samoa	UK
Belize	Egypt	Israel	Myanmar	San Marino	USA
Benin	El Salvador	Italy	Namibia	S.Tome&Pr.	Uruguay
Bermuda	Eq.Guinea	Jamaica	Nauru	Saudi Arabia	Uzbekistan
Bhutan	Eritrea	Japan	Nepal	Senegal	Vanuatu
Bolivia	Estonia	Jordan	Netherlands	Seychelles	Venezuela
Bosnia Herz.	Ethiopia	Kazakhstan	Neth.Antilles	Sierra Leone	Vietnam
Botswana	Faeroe Is.	Kenya	New Caled.	Singapore	WB&Gaza
Brazil	Falkland Is.	Kiribati	New Zealand	Slovak Rep.	W.Sahara
Brunei	Fiji	Kuwait	Nicaragua	Slovenia	Zambia
Bulgaria	Finland	Kyrgyz Rep.	Niger	Solomon Is.	Zimbabwe
Burkina Faso	France	Laos	Nigeria	Somalia	
Burundi	Fr. Guiana	Latvia	Niue	South Africa	
Cambodia	Fr.Polynesia	Lebanon	Norfolk Is.	South Korea	
Cameroon	Gabon	Lesotho	North Korea	Spain	
Canada	Gambia	Liberia	Norway	Sri Lanka	
Cape Verde	Georgia	Libya	Oman	Sudan	
Cayman Is.	Germany	Lithuania	Pakistan	Suriname	
C.AfricanRep.	Ghana	Luxembourg	Palau	Swaziland	

Table 11: Offshore Financial Centres in the sample

Origin Countries	**Destination Countries**
Aruba	Anguilla
Bahrain	Antigua and Barbuda
Bahamas	Bahamas
Barbados	Aruba
Bermuda	Bahrain
Cayman Islands	Barbados
Costa Rica	Belize
Cyprus	Bermuda
Gibraltar	Cayman Islands
Ireland	Cook Islands
Latvia	Costa Rica
Lebanon	Cyprus
Luxembourg	Dominica
Malta	Gibraltar
Mauritius	Grenada
Netherlands Antilles	Ireland
Palau	Latvia
Panama	Lebanon
Singapore	Luxembourg
Switzerland	Malta
Uruguay	Marshall Islands
Vanuatu	Mauritius
	Montserrat
	Nauru
	Netherlands Antilles
	Palau
	Panama
	Samoa
	Seychelles
	Singapore
	Switzerland
	Uruguay
	Vanuatu

Table 12: Source and description of variables

Variable	Source	Description
GDPs	CEPII gravity database	Per Capita GDPs from the World Bank's World Development Indicators (USD), in logs
Common Currency	CEPII gravity database	Dummy equals 1 if the country-pair is in a currency union in that year
Distance	CEPII GeoDist database	Bilateral distances between the biggest cities of two countries weighted by the share of the city in the overall population of the country, in logs
Common Language	CEPII GeoDist database	Dummy equals 1 if the country-pair has common official language, 0 otherwise.
Common Colonizer	CEPII GeoDist database	Dummy equals 1 if the country-pair has had common official colonizer
Common Religion	CEPII GeoDist database	Dummy equals 1 if the country-pair has had common religion
Common Legal System	CEPII GeoDist database	Dummy equals 1 if the country-pair has common legal system's origin after colonial transition
SS	Tax Justice Network	Secrecy Score, data for every other year from 2003 to 2015
CPI	Transparency International	Corruption Perception Index, yearly data from 2001
OFC	Zorom007), IMF and FSF	Dummy equals 1 if the country is considered an OFC according to one of the three listings in that year
TAX	KPMG	Corporate tax rates (percentage of GDP in that year)
EGMONT	Egmont website	Dummy equals 1 if the country is part of the Egmont group in that year
Market Capitalization	World Bank's WDI	Market capitalization of listed domestic companies (Percentage of GDP)

Figure 5: **Growth of investment flows to OFCs and non-OFCs**

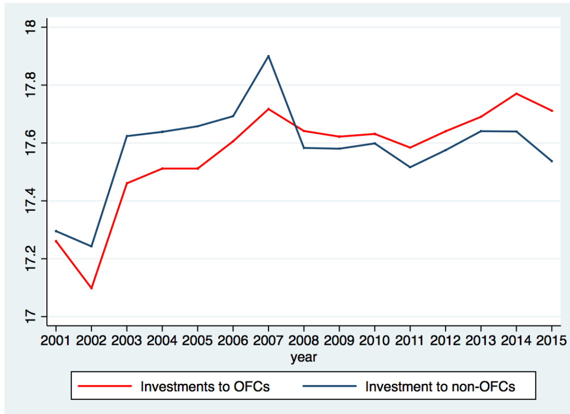

Figure 6: **Financial Secrecy in OFCs and non-OFCs**

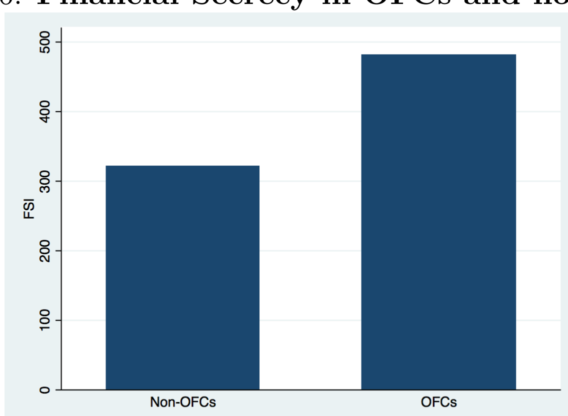

Table 14: Top 50 outliers from PPML estimation

Rank	Country	Counterpart	Year
1	United States	Cayman Islands	2014
2	United States	Cayman Islands	2015
3	United States	Ireland	2015
4	United States	Cayman Islands	2012
5	United States	Cayman Islands	2013
6	Luxembourg	United States	2014
7	United States	Cayman Islands	2011
8	United States	Ireland	2014
9	United Kingdom	Germany	2014
10	United Kingdom	United States	2008
11	United Kingdom	Germany	2015
12	France	Luxembourg	2015
13	Luxembourg	United States	2013
14	Germany	Luxembourg	2008
15	United Kingdom	United States	2009
16	United States	United Kingdom	2003
17	United Kingdom	Germany	2012
18	Japan	Cayman Islands	2010
19	United States	France	2007
20	United Kingdom	United States	2010
21	France	Germany	2007
22	United States	France	2006
23	Luxembourg	United States	2012
24	Germany	United States	2006
25	United Kingdom	France	2015
26	Luxembourg	United Kingdom	2015
27	United Kingdom	United States	2007
28	Germany	Luxembourg	2009
29	Luxembourg	United States	2015
30	United States	Germany	2007
31	United Kingdom	United States	2011
32	United States	United Kingdom	2002
33	France	Germany	2008
34	France	Ireland	2006
35	Bermuda	United States	2010
36	Germany	France	2012
37	Hong Kong	Cayman Islands	2015
38	France	Cayman Islands	2007
39	Hong Kong	China	2013
40	United States	United Kingdom	2004
41	France	Luxembourg	2014
42	Spain	Luxembourg	2015
43	Hong Kong	Cayman Islands	2010
44	Japan	United States	2015
45	United Kingdom	France	2001
46	Ireland	United States	2011
47	France	Luxembourg	2013
48	United Kingdom	Germany	2013
49	United Kingdom	Brazil	2012
50	United States	Netherlands	2015

Figure 7: **LSDV vs PPML fit**

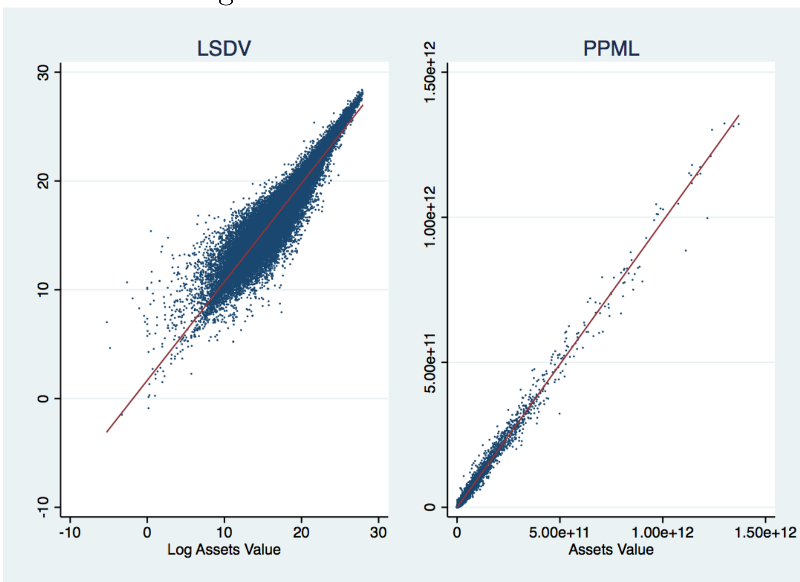

Table 16: Ordered probit estimation

VARIABLES	(1) anomaly_level	(2) anomaly_level	(3) anomaly_level	(4) anomaly_level	(5) anomaly_level	(6) anomaly_level	(7) anomaly_level
CPI_o			-0.00608*** (0.000692)	-0.00611*** (0.000902)	-0.00611*** (0.000725)	-0.00610*** (0.000948)	-0.00622*** (0.000838)
SS_o	-0.00525*** (0.000458)	-0.00599*** (0.000571)					
SS_d	-0.000351 (0.000474)	0.00320*** (0.000527)	0.000962 (0.000605)		3.38e-05 (0.000633)	0.000568 (0.000671)	0.000171 (0.000526)
OFC_d				0.228*** (0.0469)	0.228*** (0.0447)	0.275*** (0.0639)	0.248*** (0.0471)
OFC_d#c.ss_d						-0.00151 (0.00134)	
tax_o		-5.30e-05 (0.00103)	0.00388*** (0.00118)	0.00392** (0.00174)	0.00392** (0.00159)	0.00391** (0.00173)	0.00397*** (0.00136)
tax_d		0.00365*** (0.00108)	0.00333*** (0.00119)	0.00413*** (0.00116)	0.00413*** (0.00136)	0.00407*** (0.00117)	0.00476*** (0.00130)
EGMONT_d							-0.175*** (0.0545)
Constant cut1	0.994*** (0.0133)	1.400*** (0.0629)	1.182*** (0.0665)	1.235*** (0.0733)	1.236*** (0.0780)	1.243*** (0.0580)	1.105*** (0.0864)
Constant cut2	1.044*** (0.0144)	1.482*** (0.0642)	1.266*** (0.0668)	1.319*** (0.0736)	1.320*** (0.0803)	1.327*** (0.0591)	1.189*** (0.0887)
Observations	18,091	11,038	9,633	9,633	9,633	9,633	9,633

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

9 Appendix 2: Gravity of finance: the Okawa and Van Wincoop (2012) model

Okawa and Van Wincoop (2013) derive a theoretical foundation of a gravity equation for cross-border asset holdings in a one-good, two-period, N country framework. They assume there are $N+2$ assets. The gravity equation they derive refers to the first N assets, which are country-specific risky assets. Okawa and Van Wincoop refer to them as equities. In the Okawa and Van Wincoop model, the supply of assets in country i is K_i (one can think of this as capital stock). The equity claim of country i has a real payoff of D_i in the second period, where

$$D_i = 1 + \epsilon_i + \theta_i \epsilon_g.$$

ϵ_i is a country-specific payoff innovation and ϵ_g is a global payoff innovation. Although the ϵ_is are uncorrelated across is and with ϵ_g, the authors allow the response to the global innovation to be country-specific. They assume that ϵ_g has mean of 0 and variance σ_g^2.

The price of a country i equity claim in the first period is Q_i. The second asset is a riskfree bond that is in zero net supply. It has a period 1 price of Q_f. Then, there in an asset whose return is perfectly correlated with the global shock, also in zero net supply, with a period 1 price of Q_g and a period 2 payoff of

$$D_g = 1 + \theta_g \epsilon_g \tag{3}$$

We can rewrite the returns on the assets as:

$$R_i = \frac{D_i}{Q_i} \tag{4}$$

$$R_f = \frac{1}{Q_f} \tag{5}$$

$$R_g = \frac{D_g}{Q_g} \tag{6}$$

The global asset allows agents to hedge the global risk factor, so that the only risk with an impact on portfolio allocation across the N equities is the country-specific risk. This simplification of the portfolio allocation problem is critical to derive a gravity equation for bilateral asset holdings. Okawa and Van Wincoop describe three ways to interpret the global asset. One is as a global equity futures contract, allowing one to buy or sell a claim on the global equity payoff at a futures price of f^g. The payoff of this contract is

$$1 + \theta_g \epsilon_g + \sum_{i=1}^{N} (K_i/K)\epsilon_i - f^g \tag{7}$$

where K is the global capital stock and $\theta_g = \sum_{i=1}^{N}(K_i/K)\theta_i$. The payoff depends on the global shock through $\theta_g \epsilon_g$ in the same way as the assumed global asset. It is not the same as the assumed global asset when the third term that depends on the idiosyncratic shocks is not zero but, as a result of the law of large numbers, this term will be close to zero when there are many small countries.
A second possibility is to interpret the global asset as an equity futures contract on a set of multinational firms (for which country specific shocks play less of a role), and a third is to interpret the global asset as a derivative whose payoff is specifically connected to shocks that affect the entire world economy (such as an oil price futures contract). Pointing out that each of these interpretations has limitations, the authors discuss how results change not allowing for such an asset.
Agents in country j are born with an endowment of Y_j in period 1 plus a claim on all country j equity. The wealth of country j agents after period 1 consumption is

$$W_j = Y_j + Q_j K_j - C_j^1 \tag{8}$$

where C_j^1 is period 1 consumption.
In period 1 agents decide how much to consume and how to allocate the remainder of the wealth across the $N + 2$ assets. The budget constraint is

$$C_j^2 = W_j R_j^p = (Y_j + Q_j K_j - C_j^1) R_j^p \tag{9}$$

where the portfolio return is

$$R_j^p = \sum_{i=1}^{N} \alpha_{ij} R_i + \alpha_{gj} R_g + \alpha_{fj} R_f \tag{10}$$

where α_{ij} is the fraction invested in country i equity, α_{gj} that invested in the global asset and α_{fj} that invested in the riskfree one. These portfolio shares sum to 1.

Agents maximize

$$\frac{\left(C_j^1\right)^{1-\gamma}}{1-\gamma} \beta \frac{E\left(C_j^2\right)^{1-\gamma}}{1-\gamma} \tag{11}$$

with first order conditions for consumption and portfolio choice

$$\left(C_j^1\right)^{-\gamma} = \beta E\left(C_j^2\right)^{-\gamma} R_j^p \tag{12}$$

$$E\left(C_j^2\right)^{-\gamma} R_i R_f = 0 \tag{13}$$

$$E\left(C_j^2\right)^{-\gamma} R_g R_f = 0 \tag{14}$$

where (3.10) is the standard consumption Euler equation that represents the tradeoff between consumption in periods 1 and 2, (3.11) is a portfolio Euler equation that represents the tradeoff between investment in the global and riskfree asset. Equation (3.12) is a portfolio Euler equation that represents the tradeoff between investment in the global and riskfree assets.

The market clearing conditions for country i equity, the global asset and the riskfree asset are

$$\sum_{j=1}^{N} \alpha_{ij} W_j = Q_i H_i \tag{15}$$

$$\sum_{j=1}^{N} \alpha_{gj} W_j = 0 \tag{16}$$

$$\sum_{j=1}^{N} \alpha_{fj} W_j = 0 \tag{17}$$

And period 1 and 2 market clearing conditions are

$$\sum_{j=1}^{N} C_j^1 = \sum_{j=1}^{N} Y_j \tag{18}$$

$$\sum_{j=1}^{N} C_j^2 = \sum_{j=1}^{N} D_j \tag{19}$$

Okawa and Van Wincoop assume that domestic agents are more informed than foreigners about the idiosyncratic payoff innovations on domestic equity claims due to differences in language, regulatory similarities and easier access to local information. For agents in country j, ϵi has a mean of 0 and variance

$$\tau_{ij}\sigma_i^2 \tag{20}$$

Information asymmetry is therefore captured by $\tau_{ij} > \tau_{ii}$ when $i \neq j$. This assumption is fundamental for the derivation of a gravity equation for asset trade, as differently from good trade, the first one necessarily involves risk. When introducing financial frictions, it is therefore natural to relate them to risk. In solving the model the authors apply the local approximation solution method developed by Tille and Van Wincoop (2010) and Devereux and Sutherland (2011) to derive portfolio demand.

They decompose the model variables across components of different orders, where the zero order component $x(0)$ is the value of x when all standard deviations of model innovations approach zero. The first-order component is therefore proportional to model innovations, the second order component is proportional to variance and so on. There are a total of $N^2 + 5N + 4$ variables in the model: $N^2 + N$ portfolio shares α_{ij}, α_{gj}; N+2 asset prices Q_i , Q_g and Q_f ; N+2 corresponding asset returns; N period 1 consumption variables $C_{i,1}$ and N period 2 consumption variables $C_{i,2}$. There are $N^2 + 5N + 6$ equations, $N + N^2$ portfolio Euler equations; N consumption Euler equations; N+2 asset market clearing conditions; 2 goods market clearing conditions; N+2 definitions of asset returns; and N budget constraints.

As there are two periods, the authors drop two equations (due tu Walras law), namely market clearing conditions for riskfree and global assets. Imposing the zero-order components of all equations, they obtain

$$R_i(0) = R_f(0) \equiv R(0) = \frac{1}{\beta}\left(\frac{Y_w}{D_w}\right)^{\frac{-1}{\gamma}} \tag{21}$$

$$Q_i(0) = Q_g(0) = Q_f(0) = \frac{1}{R(0)} \tag{22}$$

$$C_{i,1}(0) = \frac{\beta^{\frac{-1}{\gamma}} R(0)^{\frac{1-1}{\gamma}}}{1-\beta^{\frac{-1}{\gamma}} R(0)^{\frac{1-1}{\gamma}}}\big(Y_i + Q_i(0)K_i\big) \tag{23}$$

$$C_{i,2}(0) = W_i(0) + R(0) \tag{24}$$

$$\sum_{j=1}^{N} \alpha_{ij}(0)W_j(0) = K_i Q_i(0) \tag{25}$$

where $Y_w = \sum_{i=1}^{N} Y_i$, $D_w = \sum_{i=1}^{N} D_i$ and $W_j(0) = Y_j + Q_j(0)K_j - C_{j1}(0)$.

The next step of the solution is imposing the second order component of all portfolio Euler equations (without taking the difference across countries). This gives the authors a solution to the second-order component of the N equilibrium expected excess returns.

Imposing the first order components of all equations gives

$$E\big(R_i(1)\big) = E\big(R_g(1)\big) = E\big(R_f(1)\big) \tag{26}$$

$$\big(R_i(1)\big) = R(0)(\epsilon_i + \theta_i\epsilon_g) \tag{27}$$

$$R_g(1) = R(0)(\theta_g\epsilon_g) \tag{28}$$

$$R_f(1) = Q_f(1) = Q_i(1) = Q_g(1) = 0 \tag{29}$$

$$C_{j1}(1) = 0 \tag{30}$$

$$C_{j2}(1) = W_j(0)R_j^p(1) = W_j(0)\Big(\sum_{i=1}^{N} \alpha_{ij}(0)R_i(1) + \alpha_{gj}(0)R_g(1)\Big) \tag{31}$$

Next they impose the second-order component of the portfolio Euler equations. This gives

$$C_{j2}(0)E\big(R_i(2) - R_f(2)\big) = \gamma EC_j2(1)\big(R_i(1) - R_f(1)\big) \tag{32}$$

$$C_{j2}(0)E\big(R_g(2) - R_f(2)\big) = \gamma EC_j2(1)\big(R_g(1) - R_f(1)\big) \tag{33}$$

Using the result in (27) that $R_f(1) = 0$ and the expression for C_j2 in (29), (30) and (31) can be rewritten as

$$\frac{1}{R(0)}E\big(R_i(2) - R_f(2)\big) = \gamma\sigma_g^2\theta_i\Big(\sum_{k=1}^{N} \alpha_{kj}(0)\theta_k + \alpha_{gj}(0)\theta_g\Big) + \gamma\alpha_{ij}(0)\sigma_i^2\tau_{ij} \tag{34}$$

$$\frac{1}{R(0)}E\big(R_g(2) - R_f(2)\big) = \gamma\sigma_g^2\theta_i\Big(\sum_{k=1}^{N} \alpha_{kj}(0)\theta_k + \alpha_{gj}(0)\theta_g\Big) \tag{35}$$

Substituting (32) in (33) yields

$$\alpha_i j(0) = \frac{1}{\gamma R(0)\sigma_i^2\tau_i j}\Big[E\big(R_i(2) - R_f(2)\big) - \frac{\theta_i}{\theta_g}E\big(R_g(2) - R_f(2)\big)\Big] \tag{36}$$

which is the expression for equity portfolio shares. R is therefore the zero order component of asset returns, which is the same for all assets.

Portfolio shares depend on the ratio of the expected excess return (second-order component) and the variance of the excess return. Both remove the global components as global risk can be separately hedged.

At this point, define

$$\frac{1}{p_i} = \frac{1}{\gamma R \sigma_i^2}\left[E\big(R_i - R_f\big) - \frac{\theta_i}{\theta_g}\big(R_g - R_i\big)\right] \tag{37}$$

The variable p_i is proportional to a return risk ratio: the amount of country-specific risk of asset i as captured by the variance σ_i^2, divided by the expected excess return. The higher p_i the lower the demand for the asset. The variable p_i is endogenous and it depends on the second order component of the expected excess return that in equilibrium adjusts to clear equity markets through second-order changes in asset prices. Given the definition of p_i, portfolio allocation becomes

$$\alpha_{ij} = \frac{1}{\tau_{ij} p_i} \tag{38}$$

We can interpret $\tau_{ij} p_i$ as the price (risk return ratio) faced by agents from country j investing in country i. We write total equity holdings by agents from country j as

$$E_j = \sum_{i=1}^{N} \alpha_{ij} W_j \tag{39}$$

and substituting (36) yields

$$W_j = E_j P_j \tag{40}$$

where

$$\frac{1}{P_j} = \sum_{i=1}^{N} \frac{1}{\tau_{ij} p_i} \tag{41}$$

Therefore, we can write the total equity claim $X_i j = \alpha_i j W_j$ by country j on country i as

$$X_{ij} = \frac{P_j}{\tau_{ij} P_i} E_j \tag{42}$$

Bilateral asset demand depends on a relative price: the "price" (risk return ratio) of country i equity relative to an overall price index. Similar to goods trade, a gravity specification is now derived by combining this demand equation with a set of market clearing equations. The asset market clearing condition for country i equity is

$$\sum_{j=1}^{N} X_{ij} = S_i \tag{43}$$

where $S_i = Q_i K_i$ is the country i equity supply. Also define $E = S = \sum_{j=1}^{N} E_j = \sum_{i=1}^{N} S_i$ as the world demand and supply of equity. Then (3.41) gives the following solution for p_i:

$$p_i = \frac{S}{S_i} \frac{1}{\Pi_i} \tag{44}$$

where

$$\frac{1}{\Pi_i} = \sum_{j=1}^{N} \frac{P_j}{\tau_{ij}} \frac{E_j}{E} \tag{45}$$

Then, substituting the solution for p_i back into (3.39) and (3.40) we get the gravity specification for bilateral asset holdings:

$$X_{ij} = \frac{S_i E_j}{E} \frac{\Pi_i P_j}{\tau_{ij}} \tag{46}$$

$$\frac{1}{P_j} = \sum_{i=1}^{N} \frac{\Pi_i}{\tau_{ij}} \frac{S_i}{S} \tag{47}$$

$$\frac{1}{Pi_i} = \sum_{j=1}^{N} \frac{\Pi_j}{\tau_{ij}} \frac{E_j}{E} \tag{48}$$

$$P_j E_j = Wj \tag{49}$$

For given asset supplies S_i, wealth W_j and bilateral frictions τ_{ij}, the set composed of the last three equations can be used to joinly solve for P_j, Π_i and E_j for $i = 1, ..., N$ and $j = 1, ..., N$, together with (3.44) that determines bilateral asset holdings X_{ij}.

Equation (3.44) implies that X_{ij} are driven by a size factor - i.e. the product of total equity holdings of j, E_j , and the supply of equity S_i of country i, divided by the world demand or supply. The second factor is a relative friction

$$\frac{\tau_{ij}}{\Pi_i P_j} \tag{50}$$

Here, Π_i and P_j are multilateral resistance variables that measure the average financial frictions for countries i (destination) and j (source). Given the size factor $\frac{S_i E_j}{E}$, it is this relative financial friction that drives X_{ij}. To understand why bilateral asset holdings are driven by this relative friction and not just by τ_{ij}, consider country j. Investors from j invest a total of E_j in equity. The will allocate more to countries for which τ_{ij} is low in comparison to the average financial friction P_j that it faces relative to all destination countries. The relative financial friction in (3.48) is also affected by the multilateral resistance Π_i of the destination country. When Π_i is high, country i faces high financial frictions with many source countries. In order to generate equilibrium in the market for i equity, it will have to offer a low price p_i through a high expected return. For a given bilateral barrier τ_{ij} this will raise X_{ij}.