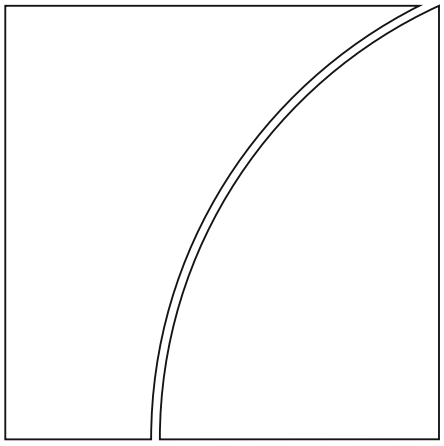

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Cross-border financial centres

Pamela Pogliani[*,‡] and Philip Wooldridge[†,‡]

July 2022

Abstract

Financial centres that cater predominantly to non-residents – which we refer to as cross-border financial centres (XFCs) –are important intermediaries of cross-border financial flows. For analysing capital flows and international interconnectedness, it can be useful to distinguish countries that are home to XFCs from other countries. We improve on previous methodologies for identifying such centres by constructing a measure focussed on the intermediation activity inherent to XFCs and explicitly taking into account the non-normal distribution of this measure across countries when detecting outliers. We also minimise volatility in the set of countries identified as XFCs over time by de-trending the data and pooling years. Our methodology identifies a core set of 12 countries as XFCs over the 1995-2020 period, but the countries vary with time and different measures of activity.

Keywords: international financial centres, offshore banks, outlier detection.

JEL classification: F21, F36, G15.

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Contents

1. Introduction

Financial centres that specialise in cross-border financial activity have become an entrenched feature of the international financial system. Until the 1970s, international financial intermediation was concentrated in a few major cities that also served as centres of domestic intermediation, notably London and New York (Kindleberger (1974)). Since then, financial centres in smaller economies have emerged as important intermediaries of cross-border financial flows. In 2020, large economies that make up the G20 accounted for a far bigger share of the global economy than of cross-border financial activity, about 80% versus 60%. The reverse was true for smaller economies home to financial centres that cater predominantly to non-residents, which we call cross-border financial centres (XFCs). XFCs are a channel for international investment, as opposed to an ultimate source or final destination for investment, and consequently have a larger global financial footprint than economic one. Thus when analysing international financial developments it can be useful to distinguish XFCs from other countries. We propose a method for identifying XFCs that is quantitative, transparent and replicable.

Analysts and researchers commonly classify countries into groups to reduce the complexity of analysing international developments. Economies and financial systems around the world differ in many ways. By grouping countries that are similar, classifications can highlight common patterns within a group of countries and differences across groups. However, classifications that are too rigid or not based on solid analytical foundations can be misleading. To be useful, classifications need to be customised depending on their purpose; classifications intended to serve one purpose may not be relevant for another. For example, some classifications serve to understand macroeconomic developments or guide investment decisions (Baudot-Trajtenberg, Turani and Upper (forthcoming)). Others are designed to determine eligibility for official development assistance or preferential market access (Alonso, Cortez and Klasen (2014)).

A classification that distinguishes XFCs from other countries is relevant for analysing capital flows and international interconnectedness. A sizable share of international assets and liabilities is domiciled in XFCs, yet many XFCs themselves are neither suppliers nor users of funds. They are financial entrepôts, channelling funds from one location to another. Depending on the type of analysis, mixing such entrepôt countries with borrower or creditor countries can make it difficult to understand developments in the latter. Indeed, Lane and Milesi-Ferretti (2018) concluded that the importance of financial centres in international investment made it difficult to separate "genuine" global financial integration from increased financial complexity. When analysing financial developments, distinguishing XFCs from other countries is important because the financial stability risks associated with XFCs are likely to be different. In contrast, when analysing macroeconomic developments, such as global growth or inflation, the usefulness of classifying some countries as XFCs is low because many XFCs are small economies with small populations.

The following section reviews the literature on the classification of financial centres. Section 3 explains our methodology, and section 4 compares our results with other methodologies. Section 5 concludes.

2. Characteristics of financial centres

A financial centre is a location, usually a city or district, where intermediaries involved in the provision of financial services are concentrated. There are several types of financial centres, which can be distinguished by a variety of characteristics. The most common way to distinguish between them is according to the location of the counterparties that they serve. This can be based on either a simple geographical distinction between residents and non-residents, or the geographical network of counterparties. Another way to

distinguish between financial centres is according to their business characteristics, in particular the range or type of services they provide or their regulatory and tax environment.

2.1 Financial sector characteristics

Starting from the standard macroeconomic distinction between residents and non-residents, financial centres can be grouped into two types: domestic and international. A domestic financial centre (DFC) serves resident counterparties; intermediaries engage with borrowers, creditors and investors located in the same country. An international financial centre (IFC) intermediates between resident and non-resident counterparties, channelling domestic savings to foreign borrowers and foreign savings to domestic borrowers. In practice, the distinction between DFCs and IFCs is not clear-cut because an IFC is often also a domestic centre. Furthermore, in open economies, domestic centres are open to foreign participation. The distinction thus depends on the size of international financial business relative to domestic activity.

IFCs where the ratio of international to domestic business is very high are sometimes referred to as offshore centres (FSF (2000), IMF (2000)). Intermediaries in offshore financial centres (OFCs) engage primarily with non-residents, channelling funds from one country to another and sometimes back to the same country in the form of round tripping.

To measure the importance of international relative to domestic activity, there are two pertinent characteristics: the type of business conducted with non-residents and the size of this business relative to that with residents. There is no consensus in the literature about which variables best capture these underlying characteristics.

Most of the literature using financial sector characteristics to distinguish among financial centres focuses on the identification of OFCs. The Bank for International Settlements (BIS), which distinguished between "offshore banking centres" and other countries for the first time in its 1976 *Annual Report*, emphasises the business of resident banks (BIS (1976)). It defines offshore centres as "countries with banking sectors dealing with non-residents and/or in foreign currency on a scale out of proportion relative to the size of the host economy" (BIS (1995)). The BIS's list of OFCs has expanded over time, from 12 countries in the 1970s to 21 since 2011 (see Annex A). Kintzler, Lé and Parra Ramirez (2019) also focus on the business of banks, and to determine whether cross-border business is disproportionately large they scale by population. This results in a list of 13 OFCs (see Annex B). They obtain similar results when scaling by the domestic activity of resident banks.

Especially since the 2007–09 financial crisis, the role of banks in the intermediation of cross-border flows has declined while that of non-bank financial institutions has increased. To the extent that some financial centres specialise in banking services and others in different types of financial services, definitions like BIS (1995) that focus narrowly on banks are likely to overestimate the importance of some centres and underestimate that of others. Zoromé (2007) adopts a broader definition that considers all types of financial intermediation, not only banking business. He defines an OFC as "a country or jurisdiction that provides financial services to non-residents on a scale that is incommensurate with the size and the financing of its domestic economy." Based on the ratio of net financial services exports to gross domestic product (GDP), Zoromé identifies 22 jurisdictions as OFCs (see Annex B).

While Zoromé's measure is broader than the BIS's, it might still miss some business with non-residents. For example, financial services exports will not capture fees related to creating and administering legal structures that manage cross-border assets, like trusts, shell companies and foundations (Tax Justice Network (2018)). Also, many countries do not disseminate the balance of payments data necessary to calculate net exports of financial services. Zoromé (2007) uses stock data from the IMF's coordinated portfolio investment survey (CPIS) to estimate missing exports data.

Fichtner (2015) builds on Zoromé's approach but considers stocks instead of flows, specifically the outstanding amount of inward foreign investment, whether in the form of portfolio investment, direct

investment or deposits. This results in a list of 16 OFCs. Lane and Milesi-Ferretti (2018) also consider the outstanding stock of foreign investment, both assets and liabilities. Based on the sum of external assets and liabilities divided by GDP, they identify 27 financial centres, which they say constitute a broader set of countries than OFCs (see Annex B).

Aside from identifying the most relevant variables, another challenge with using financial sector characteristics is determining the threshold to distinguish DFCs from IFCs, or OFCs from other IFCs. Thresholds for determining when the proportion of international to domestic business is high tend to be arbitrary. For example, Zoromé (2007) defines the threshold as one standard deviation above the mean, but calculates the mean and standard deviations separately for different income groups and excludes extreme outliers from the calculation.

2.2 Network characteristics

A more sophisticated geographical basis for distinguishing among financial centres is to consider their network of counterparties. Financial centres can be viewed as nodes in a decentralised network. Where relational data are available, the relationship of one centre with the rest of the financial system can be characterised by the number, size and nature of links. Network analysis brings to light clusters or patterns in the data that might not be readily apparent. An important limitation, however, is the need for granular data on links among countries or entities.

Within a country, subnational or provincial centres tend to be connected to a network of counterparties located nearby, whereas national centres engage with a broader set of counterparties. Among IFCs, regional centres provide services to a network of countries in close proximity, whereas global centres provide services to counterparties worldwide. While OFCs are sometimes separately distinguished, their networks can also be characterised as either regional or global.

Von Peter (2007) uses network analysis to identify international banking centres, which he refers to as "global hubs". He analyses the web of links between banks in different countries and between banks and non-banks. Through various measures of network centrality, he ranks banking centres by their importance in the network. While rankings differ depending on the measure, they are loosely correlated with market share. Xu and Corbett (2020) also analyse the global banking network. They go beyond the standard network metrics and use the PageRank algorithm to create an index of financial interconnectedness. Like von Peter (2007), their ranking is based on an absolute measure, not scaled by some indicator of domestic business, and thus large economies rank highly, led by the United Kingdom and the United States (see Annex B).

Whereas von Peter (2007) and Xu and Corbett (2020) focus on county-level links, Garcia-Bernardo, Fichtner, Takes and Heemskerk (2017) use company ownership chains. They trace company-level connections from source to intermediate and ultimate destination and distinguish between financial centres based on their place in the ownership chain. They label centres that retain foreign capital and host companies at the end of ownership chain as "sinks" and centres that act as intermediate destinations in the routing of investments as "conduits". Garcia-Bernardo, Fichtner, Takes and Heemskerk (2017) define the value of an ownership chain as the revenue of the initial company in the chain weighted by the ownership share of subsequent firms in the link. Sinks are jurisdictions where the net value entering the country scaled by GDP is at least 10, while conduits are jurisdictions where the value scaled by GDP transitioning between a sink jurisdiction and a third country is above 1 in both directions. They identify 24 sinks and 5 conduits (see Annex B).

2.3 Business characteristics

Financial centres can also be classified according to their business characteristics, such as the type or range of services that they provide (see Table 1). Some financial centres specialise in selected services, like banking, insurance, fund management or corporate support services. Others offer a full range of services.

Business characteristics to distinguish among financial centres — Table 1

Range of business	Specialised (niche) services					Full range of services
Type of business	Banking business	Non-bank business				
		Insurance	Fund management	Corporate support, eg accounting, tax	Business registry	

Business characteristics are often used to rank the competitiveness of financial centres. Z/Yen and China Development Institute (2022) publish a Global Financial Centres Index, which ranks financial centres at the city level based on information in five areas: business environment, financial sector development, infrastructure, human capital, and reputation. Over 100 cities are ranked, capturing the gamut of financial centres from provincial to global.

Some classifications focus narrowly on the regulatory and tax environment. OFCs in particular are often characterised as jurisdictions with low or zero taxation, moderate or light financial regulation, banking secrecy and anonymity (IMF (2000)). As a result, they are sometimes perceived as engaged in dubious activities and equated with tax havens (Hines (2010)). However, regulatory and tax practices in OFCs are not homogeneous, and some actively adopt and implement internationally agreed economic and financial standards (FSF (2000), IMF (2008)).

For the purpose of identifying financial centres, an important shortcoming of focussing narrowly on regulatory and tax characteristics is that these are neither necessary nor sufficient to attract non-resident business (Pogliani, von Peter and Wooldridge (2022)). A stable, transparent legal system is a prerequisite. For example, as part of Dubai's efforts to promote itself as a financial centre, the government established a special administrative area – the Dubai International Financial Centre – with its own courts as well as commercial and civil laws based on English common law.

Another shortcoming of focussing on regulatory and tax characteristics, or other business characteristics, is that they are qualitative and thus difficult to measure. Various organisations compile indicators of institutional quality and the business environment. However, these indicators often depend on normative choices about what inputs or outcomes are desirable and thus are potentially subjective. Indeed, some classifications are designed to encourage convergence to what is perceived as a more equitable international regulatory and tax environment, such as the list of uncooperative tax havens previously published by the OECD.[1]

In summary, there are several types of financial centres, and the literature distinguishes among them in a multiplicity of ways. Some classifications focus on financial sector characteristics, others network characteristics, and still others business characteristics. Some even mix these characteristics. For example, IMF (2000) combines financial sector, regulatory and tax characteristics to define OFCs as: (a) jurisdictions that have relatively large numbers of financial institutions engaged primarily in business with non-residents; (b) financial systems with external assets and liabilities out of proportion to domestic financial

[1] The OECD focuses on tax characteristics and over the years has published various lists of countries that comply with transparency and exchange of information standards for tax purposes (OECD (2009)).

intermediation designed to finance domestic economies; and (c) centres which provide some or all of the following services: low or zero taxation; moderate or light financial regulation; banking secrecy and anonymity. By combining these characteristics, in the 2000s the IMF classified 46 countries as OFCs (see Annex B).

3. Methodology

Our motivation for distinguishing XFCs from other countries is to facilitate analysis of international financial developments, such as capital flows, and risks to global financial stability, such as interconnectedness. For this purpose, we are interested in identifying financial centres that play an outsize role in the intermediation of cross-border financial flows – centres that have a larger global financial footprint than economic one. Accordingly, we distinguish among countries based on the size of international financial business relative to domestic economic activity.[2] Building on BIS (1995) and Zoromé (2007), we define a XFC as follows:

> **A cross-border financial centre is a country or jurisdiction whose external assets and liabilities are exceptionally large compared to the size of its domestic economy.**

To be useful, a classification must be relevant to the analysis for which it is used as well as replicable to ensure robustness and objectivity. While any of the characteristics discussed in section 2 could be considered relevant, a classification based on financial sector characteristics has the advantage of also being replicable. Financial sector characteristics are more easily measured than network or business characteristics. Relying on measurable, objective criteria is especially important for classifications that might inform policy recommendations (Zoromé (2007)).

Previous classifications based on financial sector characteristics have various shortcomings, such as narrow definitions of financial business, gaps in data and arbitrary thresholds. Our methodology, which is explained below, addresses these shortcomings.

Our baseline methodology uses a broad measure of international financial business, but for some purposes a narrower measure might be more appropriate. For example, contagion through interbank links is a major source of risk, and so it can be useful to identify XFCs that specialise in providing banking services to non-residents. Our methodology can be adapted for different measures of international financial business. Alongside our baseline measure, below we present a way to identify XFCs that specialise in interbank activity, which we refer to as cross-border banking centres (XBCs). Centres for cross-border fund management, insurance or other financial business could be similarly identified, but we leave that for future work.

3.1 Measuring international financial business

To measure international financial business, we refer to outstanding external assets and liabilities – also known as a country's international investment position (IIP). It is in the outstanding amounts that financial vulnerabilities build up (CGFS (2022)). As previous financial crises demonstrated, net capital flows can mask risks associated with gross quantities of inward and outward investment (Borio and Disyatat (2015), Tarashev, Avdjiev and Cohen (2016)). Furthermore, outstanding amounts tend to change slowly over time and so will result in a more stable representation of a country's role in the intermediation of cross-border flows; they capture past activity and are less sensitive to temporary changes in capital flows. The downside

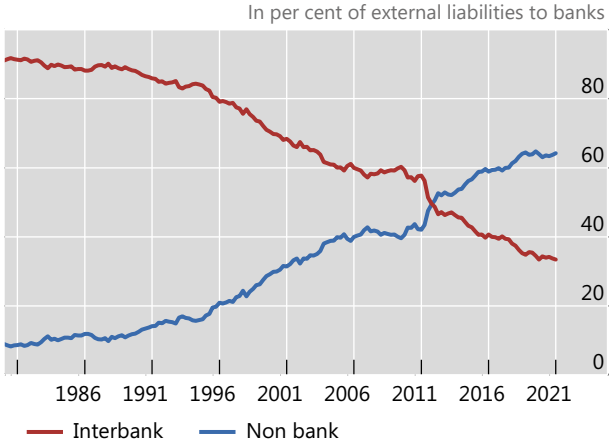
[2] XFCs might include but are not synonymous with OFCs. As discussed in section 2, OFCs are often associated with a mix of characteristics, whereas we focus exclusively on financial sector characteristics. For a discussion of what distinguishes XFCs from OFCs, see Pogliani, von Peter and Wooldridge (2022)).

of this stability is that outstanding amounts may understate the importance of upcoming financial centres that are attracting business away from established centres. Also, exchange rate fluctuations can result in large valuation effects, which introduce noise into trends in outstanding amounts.

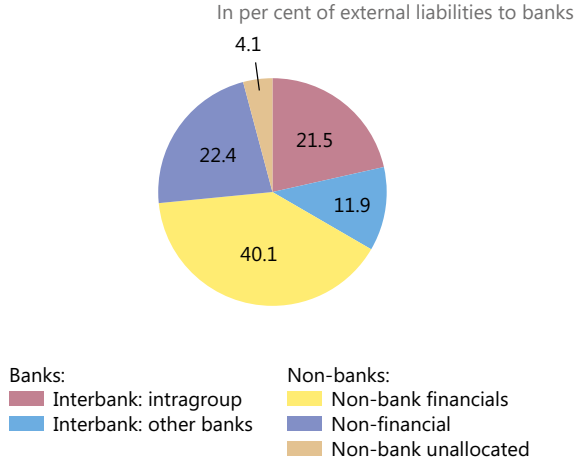
In XFCs, international financial business was once synonymous with interbank positions, but that is no longer the case. Until the mid-1990s, the bulk of cross-border financial activity in XFCs comprised business either among affiliates of the same banking group or between unrelated banks. Since then many XFCs have diversified into other activities, and today non-bank business accounts for the largest share of their cross-border activity. For example, for a large sample of XFCs, non-bank borrowers' share of external liabilities to banks rose from an average of 10% over the 1977-94 period to about 40% in 2005 and 64% in 2021 (see Graph 1, left-hand panel). In 2021 non-bank financial institutions like asset managers and insurance companies accounted for the largest share of these XFCs' liabilities to banks abroad, at 40% (right-hand panel). Banks accounted for 33%, and non-financial entities (mainly corporates) 22%.

Selected XFCs' external liabilities to banks by sector of resident borrower[1] Graph 1

Liabilities of non-banks now exceed those of banks



Non-bank financials account for the largest share[2]



[1] Data refer to cross-border claims of banks in LBS-reporting countries on borrowers residing in the 16 countries identified as XFCs in 2020 based on the intermediation ratio $XFIGDP_{i,t}$ (see Graph 5). [2] At end-December 2021.

Sources: Lane and Milesi-Ferretti (2018), updated; BIS locational banking statistics; UNCTAD; authors' calculations.

More generally, structural changes in the global financial system have increased the reliance on non-bank financial intermediation to finance growing levels of debt (FSB (2020)). They have also increased the importance of interconnectedness within the non-bank sector as well as between non-banks and banks. The 2007–09 financial crisis and 2020 Covid-19 crisis heightened policymakers' attention to the risks posed by the growing importance of non-bank financial intermediation.

These changes suggest that, for the purpose of analysing international financial developments and risks to global financial stability, the most relevant measure of international financial business is the broadest possible one, which captures all cross-border links among banks, among non-banks, and between banks and non-banks. Total external assets and liabilities from the IIP capture all such links in the form of portfolio investment, direct investment, other financial investment (consisting mainly of bank loans and deposits) and derivatives. While our baseline methodology is based in this broad measure, we complement it with a narrower measure focussed on interbank activity, as discussed above.

To focus on a country's role as a financial intermediary, as opposed to an external creditor or debtor, we take the minimum of external assets and liabilities. An important characteristic that sets XFCs apart from other financially integrated economies is that they typically have large stocks of external assets and liabilities but a small net IIP (Lane and Milesi-Ferretti (2018)). Whereas creditor countries have a net asset position, and debtors a net liability position, XFCs tend to have similarly sized external assets and liabilities because of their role as financial entrepôts – trans-shipment centres for international capital. The minimum of external assets and liabilities thus underscores a country's role as channel for borrowing and lending between foreigners, as opposed to an ultimate source or final destination for funds. We refer to this minimum measure as cross-border financial intermediation, $XFI_{i,t}$:

$$XFI_{i,t} = \min\left(XFA_{i,t}, XFL_{i,t}\right) \quad (1)$$

where $XFA_{i,t}$ refers to outstanding external financial assets of residents of country i at time t and $XFL_{i,t}$ refers to their outstanding external financial liabilities.

Admittedly, this measure captures much more than just entrepôt activity. In many countries, a large share of cross-border intermediation is driven by borrowing and lending to finance *domestic* investment and assets (Borio and Disyatat (2015)). Thus, our measure provides an upper bound on a country's role as a channel for routing investments between foreigners.[3]

We complement $XFI_{i,t}$ with a similar measure of cross-border banking intermediation $XBI_{i,t}$, which provides an upper bound for intermediation through the interbank channel:

$$XBI_{i,t} = \min\left(XBA^{b}_{i,t}, XBL^{b}_{i,t}\right) \quad (2)$$

where $XBA^{b}_{i,t}$ refers to outstanding external assets of banks in country i to all banks b abroad and $XBL^{b}_{i,t}$ refers to outstanding external interbank liabilities.

3.2 Data on external assets and liabilities

In addition to being analytically relevant for the question at hand, $XFI_{i,t}$ and $XBI_{i,t}$ have the advantage of being easily replicated because IIP data are widely available. Many countries publish IIP statistics, and for those that do not, external assets and liabilities can be derived using mirror data from publicly available creditor sources such as the BIS's locational banking statistics (LBS) and the IMF's CPIS and coordinated direct investment survey (CDIS). To calculate $XFI_{i,t}$ and $XBI_{i,t}$ we assembled a dataset covering 215 countries between 1977 and 2020, including many dependent territories.[4]

IIP was introduced as a statistical framework only in 1993 and so for many countries the history is short. Lane and Milesi-Ferretti (2018) filled this gap by estimating annual IIP data from 1970 onwards. Their estimates supplement national IIP statistics with data on cumulative flows, external debt statistics, mirror data from the CPIS and CDIS, and other national and international sources. Their coverage increases from 103 countries in 1970 to 211 in 2020, which is the final year available in the December 2021 version of their External Wealth of Nations (EWN) database.

In principle, national IIP statistics provide the most comprehensive coverage of external positions. Mirror data from creditor sources focus on a component of the IIP and so they should always be less than

[3] $XFI_{i,t}$ is similar to the measure that Lane and Milesi-Ferretti (2007) use to gauge the extent of a country's international financial integration. To measure integration, Lane and Milesi-Ferretti sum outstanding external assets and liabilities. The sum and the minimum of external assets and liabilities are highly correlated.

[4] We define "countries" as jurisdictions with country codes officially assigned under the ISO 3166-1 standard. In addition to sovereign states, ISO country codes cover dependent territories for which data are separately and independently maintained. As of end-2020, ISO assigned country codes to 249 countries, territories or areas of geographical interest. Most of the codes excluded from our sample refer to uninhabited islands. Several territories and countries are excluded because either data are not available, including the Vatican, or are not available separately from the data of an associated country, such as Monaco and Puerto Rico (aggregated in the national statistics of France and the United States, respectively).

IIP statistics. In practice, national sources sometimes underestimate external assets and liabilities. This is because there is an incentive for assets held abroad to be underreported (Pellegrini, Sanelli and Tosti (2016)). Furthermore, some national statistics have incomplete coverage of positions booked in special zones or by entities that engage mainly with non-residents. For example, the IIP statistics published by the Cayman Islands exclude data on entities without a physical presence in the islands (ESO (2020)). As a result, they exclude the assets and liabilities of funds and other entities that are registered and legally domiciled in the Cayman Islands but engage exclusively with non-residents and have little or no physical presence.

In the EWN, national statistics are adjusted for incomplete data using various sources. However, mirror data from the LBS are not fully incorporated. For some countries, external assets and liabilities derived from the LBS – banks' cross-border liabilities and assets, respectively – are much higher than national data. While the EWN acknowledges discrepancies with the LBS and possible reasons for them, the EWN gives preference to national data.

We extend the EWN by giving preference to the LBS instead (see Annex C). The LBS are available quarterly from 1977. Where external assets and liabilities derived from the LBS are higher than estimates in the EWN, we replace the estimates. Overall, about 6% of observations from EWN are replaced by LBS (see Table 2). As expected, the number of replacements is much higher for external assets than liabilities. Furthermore, replacements are concentrated in around 20 countries. Among the countries with the highest number of replacements are Liberia, Barbados, Panama and Vanuatu.

By fully incorporating the LBS, we are also able to expand the sample of countries because the LBS cover more countries than the EWN. For example, in 1977 the LBS cover about 150 countries and the EWN only 132, and in 1990 around 170 compared to 159. Overall, our final sample is about 7% larger than the EWN sample.

Another advantage of the LBS is that, unlike IIP statistics, they provide data by sector of the counterparty. Therefore, to measure $XBI_{i,t}$ data on cross-border interbank positions are sourced solely from the LBS. By fully incorporating the LBS into our estimates of external positions, we ensure consistency between data sources for $XFI_{i,t}$ and $XBI_{i,t}$.

Sources of data on external assets and liabilities

Number of observations, 1977-2020 Table 2

	$XFA_{i,t}$	$XFL_{i,t}$	$XFIGDP_{i,t}$	$XBIGDP_{i,t}$
Data from EWN[1]	8013	8016		
Data available in EWN but replaced by LBS[2]	743	240		
Data not available in EWN but available in LBS[2,3]	569	519		
Final sample	8582	8535	8554	8187

[1] Version of EWN published in December 2021. Excludes countries without officially assigned ISO codes (euro area, ECCB, Kosovo). [2] Version of LBS published in June 2022. [3] Data for 5 countries are available only in LBS: Bonaire, St Eustatius and Saba (BQ), Cuba (CU), Greenland (GL), North Korea (KP), and St Helena (SH). For 46 other countries, a longer time series is available in LBS: 8 additional years on average, but ranging from 1 to 28 years.

Sources: BIS locational banking statistics; Lane and Milesi-Ferretti (2018), updated; UNCTAD; authors' calculations.

3.3 Scaling and outlier detection

Our methodology for distinguishing XFCs from other countries depends on scaling $XFI_{i,t}$ and $XBI_{i,t}$ by domestic activity. XFCs and XBCs are then identified as outliers in the distribution of the resulting ratio across countries.

Previous studies scaled by GDP, population or resident banks' local assets. Gross national income (GNI) is another option, in order to remove the share of GDP earned by non-residents, which in XFCs is larger than the foreign income earned by residents. While a case can be made for scaling by any of these variables, we opt for GDP. GDP is the most common metric for measuring the size of the domestic economy. Consequently, it is readily available for most countries, including many dependent territories.[5]

The ratio of $XFI_{i,t}$ to GDP and $XBI_{i,t}$ to GDP gives our preferred measures for comparing international business to domestic activity, as shown in equations (3) and (4):

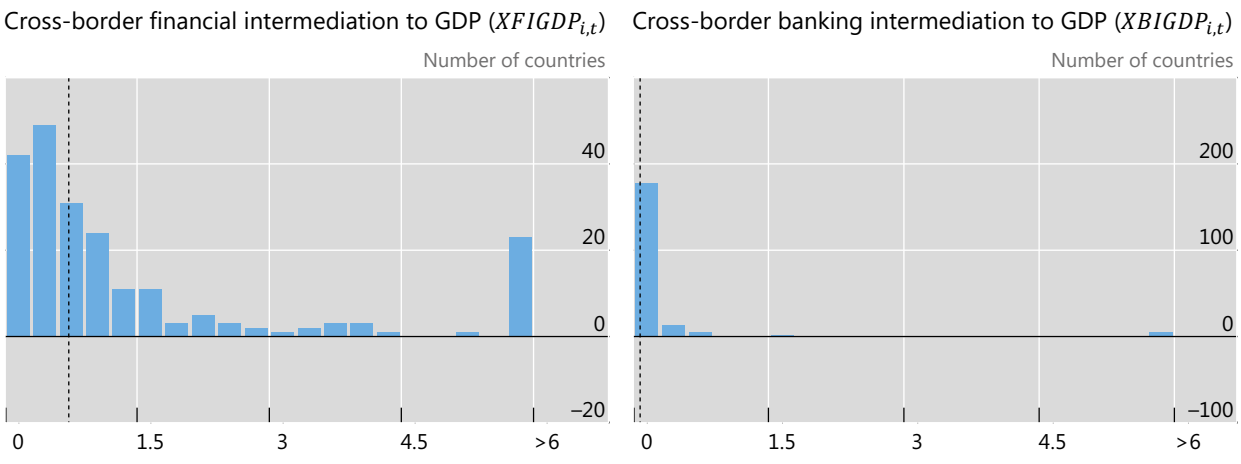
$$XFIGDP_{i,t} = \frac{\min(XFA_{i,t}, XFL_{i,t})}{GDP_{i,t}} \quad (3)$$

$$XBIGDP_{i,t} = \frac{\min(XBA^{b}_{i,t}, XBL^{b}_{i,t})}{GDP_{i,t}} \quad (4)$$

Across countries, $XFIGDP_{i,t}$ and $XBIGDP_{i,t}$ are distributed over a wide range because of differences in capital account openness, economic structure and financial development, among other factors. Owing to their specialisation in providing financial and business services to non-residents, we expect XFCs to stand out as countries for which these observations deviate markedly from other countries. Statistically, they are outliers in the distribution of $XFIGDP_{i,t}$ and $XBIGDP_{i,t}$. When the ratio falls above the upper threshold separating outliers in the right tail from the rest of the distribution, we set the dummy variable $DXFC_{i,t}$ equal to 1 to indicate a XFC and zero otherwise. To indicate XBCs we define the dummy variable $DXBC_{i,t}$ in the same way.

The challenge is to identify a robust threshold for separating XFCs from the main cluster of countries, meaning a threshold that is not sensitive to the extreme values that it is intended to detect. For our sample, the most important consideration when deciding on the outlier detection technique is the non-normality of the distribution. As shown in Graph 2 and Table 3, the distributions of $XFIGDP_{i,t}$ and $XBIGDP_{i,t}$ are highly right skewed. Some observations are so far to the right of the median that they are clearly outliers. Other observations are less extreme but could still be outliers. The Shapiro Wilk test confirms that the data are not normally distributed.[6]

Histogram of cross-border intermediation ratios: 2020 data — Graph 2



Dashed vertical line represents the median ($XFIGDP_{i,t}$ = 0.73, $XBIGDP_{i,t}$ = 0.03).

Sources: BIS locational banking statistics; Lane and Milesi-Ferretti (2018), updated; UNCTAD; authors' calculations.

[5] For most countries, we source GDP data from EWN. We supplement EWN with GDP data from UNCTAD and fill in missing years by extrapolating data from previous years.

[6] Even if $XFIGDP_{i,t}$ and $XBIGDP_{i,t}$ are transformed into logs, the distributions remain fat tailed, with high kurtosis.

Summary statistics and outliers: 2020 data[1] Table 3

	$XFIGDP_{i,t}$		$\delta XFI_{i,t}$		$XBIGDP_{i,t}$		$\delta XBI_{i,t}$	
Summary statistics								
N	215		215		207		207	
Mean	16.6		-0.1		0.6		-0.1	
Median	0.7		-0.3		0.0		-0.2	
Minimum	0.0		-6.0		0.0		-4.3	
Maximum	1,497.1		7.2		59.7		7.5	
Standard deviation	123.1		1.7		4.4		1.9	
MAD	0.7		1.2		0.0		1.7	
Fat tails								
Skewness	10.3		1.0		12.1		0.7	
Kurtosis	111.6		6.6		156.2		4.1	
Normality (Shapiro Wilk test)[1]	0.0		0.0		0.0		0.0	
Medcouple	0.5		0.1		0.6		-0.0	
Both tails: number of outliers (share)								
Mean±3 standard deviations	2	(0.9%)	5	(2.3%)	2	(1.0%)	2	(1.0%)
Standard boxplot	32	(14.9%)	16	(7.4%)	33	(15.9%)	6	(2.9%)
Adjusted boxplot	30	(13.9%)	17	(7.9%)	11	(5.3%)	7	(3.4%)
Median±3 MAD	35	(16.3%)	14	(6.5%)	43	(20.8%)	5	(2.4%)
Right tail: number of outliers (upper threshold)								
Mean+3 standard deviations	2	(386.1)	4	(5.0)	2	(13.8)	2	(5.8)
Standard boxplot	32	(3.6)	13	(2.8)	33	(0.2)	6	(4.3)
Adjusted boxplot	16	(10.9)	8	(3.6)	11	(0.9)	7	(4.2)
Median+3 MAD	35	(2.7)	11	(3.2)	43	(0.2)	5	(4.9)

[1] The Shapiro-Wilk test tests the null hypothesis that a sample originates from a normal distribution. The value reported is the p-value of the test. Normality can therefore be rejected for all measures.

Sources: BIS locational banking statistics; Lane and Milesi-Ferretti (2018), UNCTAD; authors' calculations.

Owing to the non-normality of $XFIGDP_{i,t}$ and $XBIGDP_{i,t}$, non-parametric techniques are more robust than parametric techniques for separating outliers from the main cluster of observations. Parametric techniques, such as 3 standard deviations from the mean, rely on measures that are substantially influenced by extreme values. In particular, the mean and standard deviation have a breakdown point of zero, meaning that a single datapoint can change these measures by an arbitrarily large amount (Wilcox (2021)). Non-parametric techniques for calculating outlier thresholds are less sensitive to extreme values. Three examples are shown in Table 4: the standard boxplot based on the interquartile range (IQR), the adjusted boxplot incorporating the medcouple (MC) and the median absolute deviation (MAD). The measures used in each of these techniques have a breakdown point of 0.25 or more, meaning that at least 25% of observations would need to change to have a significant impact on the measure.

Among the three non-parametric techniques that we consider, the adjusted boxplot is the most appropriate owing to the skewness of $XFIGDP_{i,t}$ and $XBIGDP_{i,t}$,. The IQR and MAD are robust estimators for symmetric distributions but can give misleading results for skewed or multimodal distributions; for skewed distributions, they tend to identify too many observations in the longest tail as outliers. The MC is

a robust measure of skewness. Its incorporation into the adjusted boxplot shifts the lower and upper thresholds in the direction of the longest tail. As a result, the number of outliers in the right tail is much lower based on the adjusted boxplot: 16 for $XFIGDP_{i,t}$ and 11 for $XBIGDP_{i,t}$,, compared to over 30 based on the other two techniques (see Table 3).

Non-parametric techniques for detecting outliers — Table 4

Technique	Upper threshold	
Standard boxplot	$Q_{3,t} + 1.5\ IQR_t$	where Q_3 is the third quartile and IQR is the interquartile range between the first and third quartiles
Adjusted boxplot	$Q_{3,t} + 1.5e^{3MC_t} IQR_t$	where MC is the medcouple[1] (see Annex D)
Based on MAD	$Q_{2,t} + 3\ MAD_t$	where Q_2 is the median and MAD is the median absolute deviation[2]

[1] This defines the upper threshold when $MC \geq 0$. If $MC < 0$, the upper threshold is $Q_{3,t} + 1.5e^{4MC_t} IQR_t$. [2] MAD is defined as $1.48\ [median(|x_{i,t} - Q_{2,t}|)]$ where $x_{i,t}$ is the underlying series (eg $XFIGDP_{i,t}$ or $\partial XFI_{i,t}$).

Source: Authors' calculations.

3.4 Stability over time

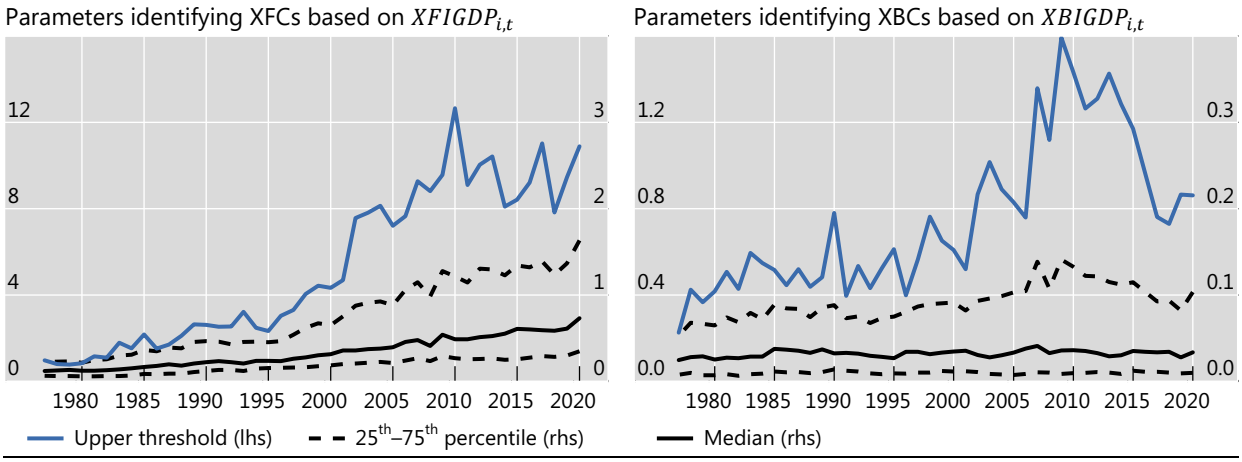
Ideally the outlier detection technique would identify a set of XFCs and XBCs that is relatively stable over time. A country's standing as a XFC or XBC is underpinned by various structural characteristics. Some of these characteristics are static, such as geography (Pogliani, von Peter and Wooldridge (2022)). Others change but usually over the medium to long term, such as taxation and regulation. Consequently, the group of countries identified as XFCs or XBCs is not expected to change frequently.

When applied to the distribution of $XFIGDP_{i,t}$ and $XBIGDP_{i,t}$, the adjusted boxplot results in a relatively high number of changes in the set of XFCs and XBCs each year. Over the 1977-2020 sample, the sum of entries and exits (excluding entries due to countries joining the sample) averaged 1.4 for $XFIGDP_{i,t}$ and 2.6 for $XBIGDP_{i,t}$. Furthermore, the outlier threshold trends upward over time (see Graph 3). In other words, the determination of whether external assets and liabilities are exceptionally large compared to the size of the domestic economy is a function of time; ratios that were exceptionally large one year might not be a few years later. Such variation is difficult to reconcile with the structural characteristics that underpin financial centres.

This variation is explained in large part by the trend increase in external assets and liabilities over our sample. The rise in cross-border intermediation was especially stark among countries above the median. Looking at $XFIGDP_{i,t}$, the third quartile and upper threshold have diverged ever more from the median since the 1970s (see Graph 3). For $XBIGDP_{i,t}$, the divergence peaked in 2007, and since 2012 the distribution has become less skewed.

Cross-border intermediation ratios over time

Graph 3



Sources: Lane and Milesi-Ferretti (2018), updated; BIS locational banking statistics; UNCTAD; authors' calculations.

To identify a more stable set of XFCs and XBCs, we de-trend the data and pool all years in our sample. The outlier threshold is then calculated by applying the adjusted boxplot to the pooled sample of detrended data. To de-trend the data, we regress cross-border intermediation on GDP plus a time trend, as shown in equations (5) and (6). Logged values of $XFI_{i,t}$, $XBI_{i,t}$ and $GDP_{i,t}$ are used to remove their exponential trend.

$$\widehat{\ln(XFI_{i,t})} = -101.74 + 0.99\ \ln\left(GDP_{i,t}\right) + 0.05\ YEAR_t \qquad (5)$$

$$\widehat{\ln(XBI_{i,t})} = -9.24 + 1.08 \ln\left(GDP_{i,t}\right) + 0.01\ YEAR_t \qquad (6)$$

The detrended data are calculated as the difference between the actual and predicted values of $XFI_{i,t}$ and $XBI_{i,t}$:

$$\delta XFI_{i,t} = \ln(XFI_{i,t}) - \widehat{\ln(XFI_{i,t})} \qquad (7)$$

$$\delta XBI_{i,t} = \ln(XBI_{i,t}) - \widehat{\ln(XBI_{i,t})} \qquad (8)$$

Detrending the data in this way ensures that the ordinal ranking of countries in any given year is the same as for $XFIGDP_{i,t}$ and $XBIGDP_{i,t}$..

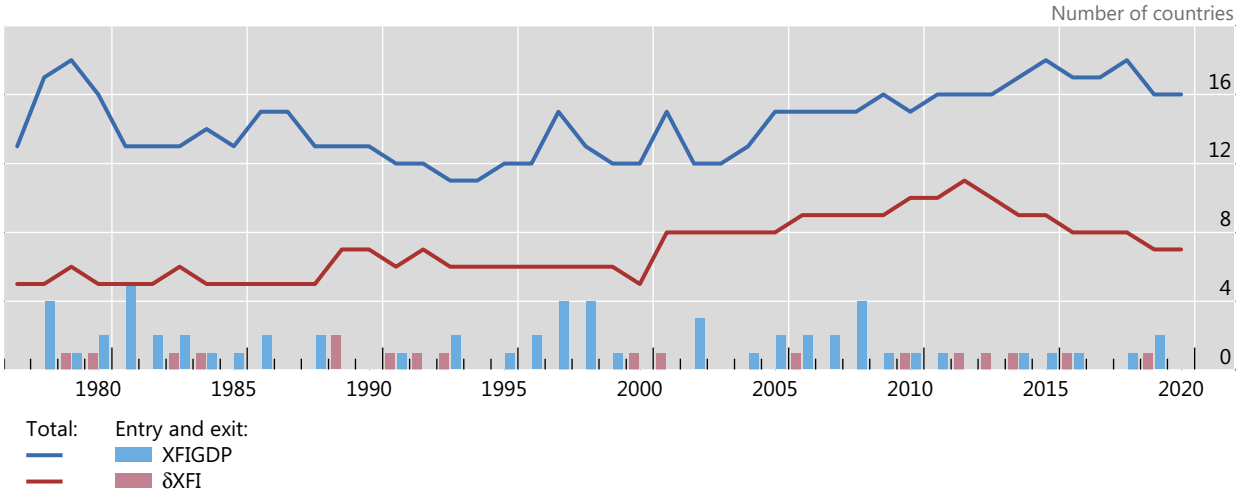
De-trending the data results in a more stable set of XFCs and XBCs over time. The sum of exits and entries averaged 0.4 for XFCs and 1 for XBCs (see Graph 4). The de-trended measures also result in a smaller number of XFCs and XBCs, mainly because taking logs of cross-border intermediation and GDP reduces the skewness of their distribution. The more symmetric are the data, the more similar are the results of the various outlier detection techniques (see Table 3). Based on $\delta XFI_{i,t}$, the number of XFCs ranges from a low of 5 to a high of 11 (see Graph 4). This compares to a range of 11 to 18 based on $XFIGDP_{i,t}$. The range for XBCs is similar but more volatile.

Based on the de-trended measure $\delta XFI_{i,t}$,, the conditional probability of being identified as a XFC in year t+1 given that a country is a XFC in year t is 97%. This compares to 95% based on the intermediation ratio $XFIGDP_{i,t}$. The conditional probability of being identified as a XBC is 94% based on $\delta XBI_{i,t}$, compared to 90% based on $XBIGDP_{i,t}$.

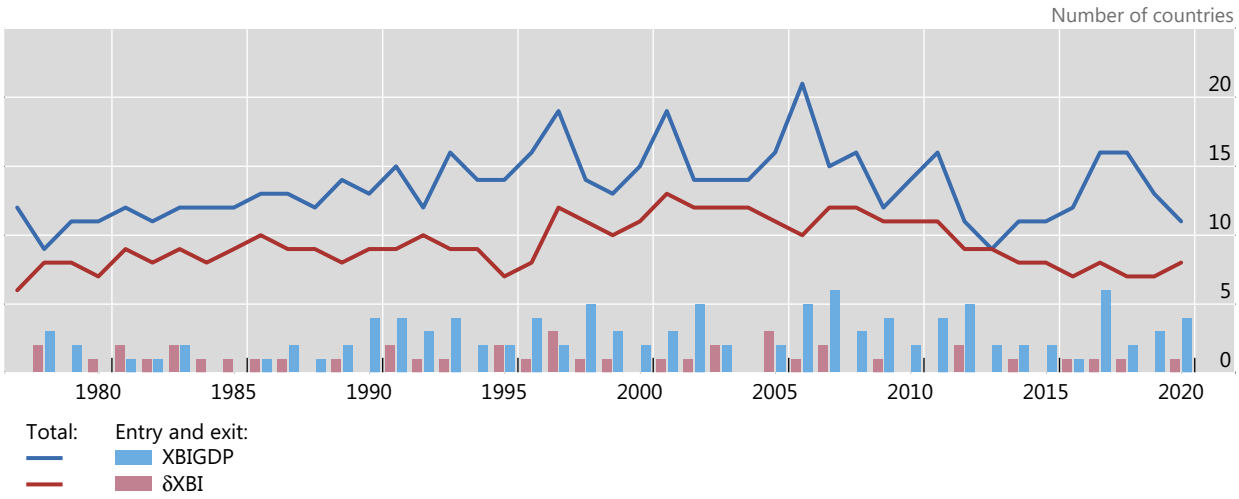
Number of cross-border financial and banking centres over time

Comparison of results based on annual intermediation ratios and de-trended measures Graph 4

Cross-border financial centres (XFCs)



Cross-border banking centres (XBCs)



Sum of entries and exits excludes the entry of countries for which data were not available in the previous year.

Sources: BIS locational banking statistics; Lane and Milesi-Ferretti (2018), updated; UNCTAD; authors' calculations.

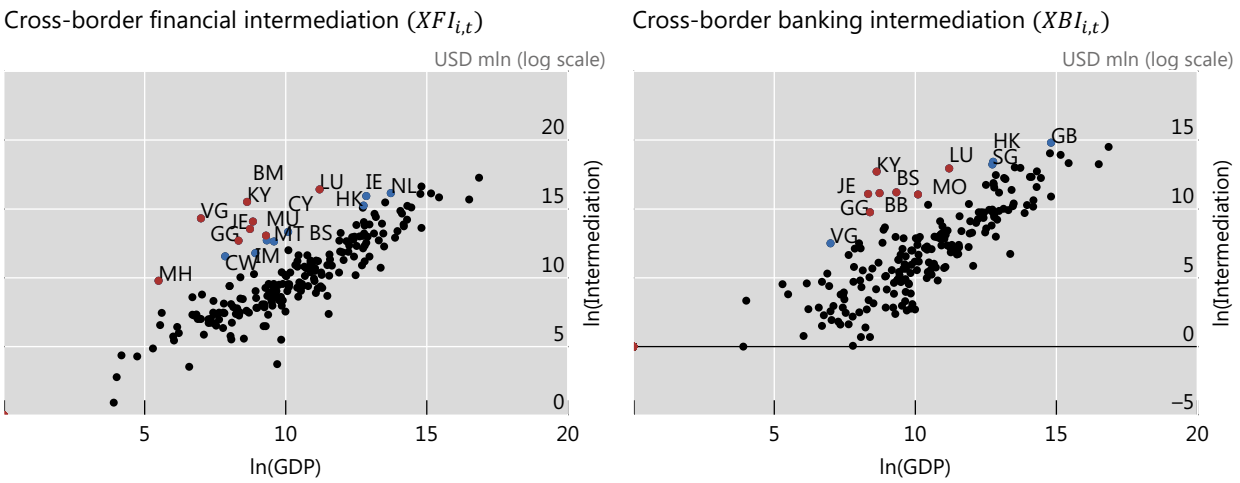
4. Results

In 2020 our methodology identifies 7 countries as XFCs based on the detrended measure $\delta XFI_{i,t}$ and a somewhat different 8 as XBCs based on $\delta XBI_{i,t}$. British Virgin Islands (VG), Cayman Islands (KY), Guernsey (GG), Jersey (JE) and Luxembourg (LU) are identified as both XFCs and XBCs. Bermuda (BM) and Marshall Islands (MH) are also identified as XFCs, while Bahamas (BS), Barbados (BB) and Macao SAR (MO) are identified as XBCs. In this section, we assess the sensitivity of our results to changes in the variables used to measure international business and domestic activity.

4.1 Comparison of core and broad sets

As discussed in section 3, the detrended measures $\delta XFI_{i,t}$ and $\delta XBI_{i,t}$ identify a smaller, more stable set of countries as XFCs and XBCs, respectively, than the intermediation ratios $XFIGDP_{i,t}$ and $XBIGDP_{i,t}$. The core set of countries identified by the detrended measures convincingly meets the definition of a XFC as a country whose external assets and liabilities are exceptionally large compared to the size of its domestic economy. The scatter plot in Graph 5 confirms that the outliers identified by our detrended measures, marked as red dots, stand out clearly from the sample; these countries have much larger external assets and liabilities relative to other countries with similar GDP levels.

GDP and cross-border intermediation in 2020 Graph 5



Red dots indicates countries identified as XFCs based on the detrended measure $\delta XFI_{i,t}$ (left-hand panel) or XBCs based on $\delta XBI_{i,t}$ (right-hand panel). Blue dots indicates countries identified as XFCs based on the ratio $XFIGDP_{i,t}$ (left-hand panel) or XBCs based on $XBIGDP_{i,t}$ (right-hand panel).

BB=Barbados; BM=Bermuda; BS=Bahamas; CW=Curaçao; CY=Cyprus; GB=United Kingdom; GG=Guernsey; HK=Hong Kong SAR; IE=Ireland; IM=Isle of Man; JE=Jersey; KY=Cayman Islands; LU=Luxembourg; MH=Marshall Islands; MO=Macao SAR; MT=Malta; MU=Mauritius; NL=Netherlands; SG=Singapore; VG=British Virgin Islands.

Sources: BIS locational banking statistics; Lane and Milesi-Ferretti (2018), updated; UNCTAD; authors' calculations.

That said, for some analytical purposes a broader set of financial centres based on the intermediation ratios $XFIGDP_{i,t}$ and $XBIGDP_{i,t}$. might be more useful than the core set based on $\delta XFI_{i,t}$ and $\delta XBI_{i,t}$. For example, the broader set might include upcoming centres or centres specialised in niche services. In 2020, the broader set of XFCs and XBCs totalled 16 and 11 countries, respectively. These countries, which are marked as blue dots in Graph 5, also distance themselves from the main cluster of countries but less strikingly than the core set.

Notwithstanding variation over time in the core and broad sets, the countries identified as XFCs or XBCs are concentrated. Over the 1995-2020 period, only 12 were identified as XFCs in at least one year based on the detrended measure $\delta XFI_{i,t}$, each for an average of about 18 years (see Table 5 and Annex F). The number identified as XFCs based on $XFIGDP_{i,t}$ was twice as high, at 26. Based on $\delta XBI_{i,t}$, 19 countries were identified as XBCs in at least one year over the 1995-2020 period, each for an average of almost 14 years (see Table 5 and Annex G). Based on $XBIGDP_{i,t}$, the universe identified as XBCs was 32.

While there is substantial overlap between countries identified as XFCs and those identified as XBCs, there are also many differences. Among the 26 countries in the broad set of XFCs over the 1995-2020 period, 4 are not included in the broad set of XBCs (see Table 5). Similarly, among the 32 countries in the broad set of XBCs, 10 are not included in the broad set of XFCs. This indicates that the alternative ways of measuring international financial business – as financial intermediation XFI or banking intermediation XBI – are capturing different information.

Prior to the mid-1990s, there were fewer differences between XFCs and XBCs. For the broad set, the conditional probability of a county being identified as a XFC given that it was identified as a XBC fell from 85% over the 1977-1994 period to 73% over the 1995-2020 period. This is consistent with the shift in XFCs' financial business away from interbank activity from the mid-1990s onwards.

Universe of cross-border financial and banking centres — Table 5

		Cross-border financial centres (XFCs)			Not in core or broad set of XFCs
		Core set in 2020 (7)	Core set in 1995-2020 (12)[1]	Broad set in 1995-2020 (26)[2]	
Cross-border banking centres (XBCs)	Core set in 2020 (8)	British Virgin Isl. (VG) Cayman Islands (KY) Guernsey (GG) Jersey (JE) Luxembourg (LU)	Bahamas (BS)	Barbados (BB)	Macao SAR (MO)
	Core set in 1995-2020 (19)[1]	Bermuda (BM) Marshall Islands (MH)	Curaçao (CW) Gibraltar (GI) Liberia (LR)	Bahrain (BH) Isle of Man (IM) Nauru (NR) Singapore (SG) Vanuatu (VU)	St Helena (SH)
	Broad set in 1995-2020 (32)[2]			Cyprus (CY) Hong Kong SAR (HK) Ireland (IE) Malta (MT) Panama (PA)	Belgium (BE) Iceland (IS) Kiribati (KI) Liechtenstein (LI) St. Vincent (VC) Switzerland (CH) Tuvalu (TV) United Kingdom (GB)
Not in core or broad set of XBCs			Mauritius (MU)	Netherlands (NL) Samoa (WS) San Marino (SM)	

[1] Countries identified as being a XFC/XBC in at least one year over the 1995-2020 period according to the detrended measure. Includes all countries shown in the core set in 2020. [2] Countries identified as being a XFC/XBC in at least one year over the 1995-2020 period according to the cross-border intermediation ratio. Includes all countries shown in the core sets.

Source: Authors' calculations.

4.2 Comparison with other measures

To assess the robustness of our results, we compare them to alternative measures for identifying financial centres. We focus on measures that can be readily updated because, as shown above, the identification of XFCs is sensitive to the period selected. To focus on differences in the variables selected rather than outlier detection techniques, we compare outcomes from the adjusted boxplot method and without de-trending the data.

First, we consider an alternative measure of international financial business. Following Zoromé (2007), we substitute net exports of financial services for the minimum of external assets and liabilities in equation (3). Tax Justice Network (2020) complements national data on financial services exports with estimates following the method proposed by Zoromé, resulting in a sample of 129 countries. Using financial services exports and identifying outliers with the adjusted boxplot, the number of countries identified as XFCs is 11 (see Table 6). For the same sample of countries, $XFIGDP_{i,t}$ identifies 9 countries as XFCs, of which 6 are identified by both measures. The overlap is thus 43%, which is the same as the overlap between $XFIGDP_{i,t}$ and $XBIGDP_{i,t}$ at 40%. This confirms that the information captured by XFI differs from that captured by financial services exports and banking intermediation. The overlap between $XBIGDP_{i,t}$ and financial services export is lower at 29%.

Next we consider alternative scaling measures by replacing GDP with population, as proposed by Kintzler, Lé and Parra Ramirez (2019), and with GNI. When scaling by GNI the overlap with the measure scaled by GDP is high for both XFI and XBI ; the overlap is 100% and 92% for the respective measures (see Table 6). Scaled by population the overlap with our preferred measure is lower but still high at 65% for XFI and 56% for XBI.

Comparison of alternative measures for identifying financial centres — Table 6

Data for 2020; outliers are detected using the adjusted boxplot

X	Y	Sample size[1]	Total number of XFCs/XBCs		Number of common XFCs/XBCs	Number of unique XFCs/XBCs		Overlap = common / (common + unique)
			X	Y	X and Y	Unique to X	Unique to Y	
Alternative numerator (measuring international financial business)								
$XFIGDP_{i,t}$	$XBIGDP_{i,t}$	207	17	11	8	9	3	40%
$\delta XFI_{i,t}$	$\delta XBI_{i,t}$	207	7	8	5	2	3	50%
$XFIGDP_{i,t}$	$Exports/GDP_{i,t}$[2]	129	9	11	6	3	5	43%
$XBIGDP_{i,t}$	$Exports/GDP_{i,t}$[2]	124	6	12	4	2	8	29%
Alternative denominator (measuring business with residents)								
$XFIGDP_{i,t}$	$XFI/GNI_{i,t}$	202	14	14	14	0	0	100%
$XBIGDP_{i,t}$	$XBI/GNI_{i,t}$	197	12	11	11	1	0	92%
$XFIGDP_{i,t}$	$XFI/Population_{i,t}$	210	15	13	11	4	2	65%
$XBIGDP_{i,t}$	$XBI/Population_{i,t}$	202	10	15	9	1	6	56%

[1] Due to data availability, the sample size varies across comparisons. [2] $Exports/GDP_{i,t}$ = net financial services exports/GDP.

Sources: Tax Justice Network; United Nations; World Bank; authors' calculations.

These comparisons indicate that our results are more sensitive to the variable selected for measuring international financial business than for measuring domestic business, ie more sensitive to the

choice of numerator for the cross-border intermediation ratio than the choice of denominator. This suggests a high degree of heterogeneity among financial centres in their business characteristics and range of activities.

5. Conclusions

Financial centres that cater to non-residents are important intermediaries of cross-border financial flows. Thus when analysing international financial developments and monitoring risks to global financial stability it can be useful to distinguish countries that are home to such centres from other countries. We define cross-border financial centres as countries whose external assets and liabilities are exceptionally large compared to the size of their domestic economy. In addition to being analytically relevant, this definition leads to a quantitative, transparent and replicable methodology for identifying XFCs.

Our methodology improves on previous schemes for classifying XFCs in three ways. First, we capture the intermediation activity inherent to XFCs by taking the minimum of external assets and liabilities. Second, we explicitly account for the non-normality of the distribution when deciding on the threshold for separating XFCs from the main cluster of countries. Third, we minimise volatility in the set of countries identified as XFCs over time by de-trending the data and pooling years. While de-trending and pooling results in a more stable set of XFCs than results based on annual data, this core set still varies over time, and thus the set of XFCs will depend on the period being analysed.

An important avenue for further research is understanding what type of financial business each XFC undertakes with non-residents. Our results are sensitive to how such business is measured. We construct two measures of external assets and liabilities, one that captures all financial business (cross-border financial intermediation) and another that focuses on interbank business (cross-border banking intermediation). They result in different sets of XFCs and XBCs. Focussing on financial services exports instead of assets and liabilities results in yet another set. While several countries are common to all sets regardless of how financial business with non-residents is measured, the variation suggests that some XFCs specialise in selected services. Depending on the issue being analysed, it might be useful to distinguish among XFCs based on a narrower measure than cross-border financial intermediation.

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Annex A BIS's list of offshore centres

Year when the published list changed[1]		1976	1995	2002	2003	2006	2011
Total		12	14	17	19	20	21
Aruba	AW		X	X	X	X	X
Bahamas	BS	X	X	X	X	X	X
Bahrain	BH		X	X	X	X	X
Barbados	BB	X	X	X	X	X	X
Bermuda	BM	X	X	X	X	X	X
VG and West Indies[2]	VG	X	X	X	X	X	X
Cayman Islands	KY	X	X	X	X	X	X
Gibraltar	GI				X	X	X
Guernsey	GG			X	X	X	X
Hong Kong SAR	HK	X	X	X	X	X	X
Isle of Man	IM			X	X	X	X
Jersey	JE			X	X	X	X
Lebanon	LB	X	X	X	X	X	X
Liberia	LR	X	X	X			
Macao SAR	MO				X	X	X
Mauritius	MU				X	X	X
Netherlands Antilles[3]	AN	X	X	X	X	X	
Curaçao	CW						X
Sint Maarten	SX						X
Panama	PA	X	X	X	X	X	X
Samoa	WS					X	X
Singapore	SG	X	X	X	X	X	X
Vanuatu	VU	X	X	X	X	X	X

[1] In 2002 the BIS proposed to the Inter-Agency Task Force on Finance Statistics that an offshore financial centre be defined as "a jurisdiction in which its international investment position assets, including as resident all entities that have legal domicile in that jurisdiction, are close to or more than 50 percent of GDP and in absolute terms more than $1 billion" (IMF (2002)). Based on this definition, the BIS identified 20 countries as OFCs. The definition was not adopted. The proposed list contained a few countries that the BIS has never included in its published list of offshore centres, in particular Luxembourg and Switzerland. [2] British Virgin Islands (VG) are not shown separately by the BIS. They are included in a BIS-defined country grouping called "West Indies UK", together with Anguilla (AI), Antigua and Barbuda (AG), Montserrat (MS) and St Kitts and Nevis (KN). According to data from Dealogic, at end-2019 residents of VG accounted for 100% of the outstanding stock of international debt securities issued by residents of the West Indies UK, confirming that BIS data for the West Indies UK can be allocated to VG. [3] At end-2010 the Netherlands Antilles (AN) dissolved and its constituents became the countries of Curaçao (CW) and Sint Maarten (SX) plus three special municipalities within the Netherlands, Bonaire, Sint Eustatius and Saba (BQ).

Sources: *BIS Annual Report*, various editions; *BIS Quarterly Review*, various editions.

Annex B Financial centres according to different measures

Country	ISO	Financial sector characteristics			Network characteristics		Mix of characteristics
		Kintzler et al (2019)	Zoromé (2007)	Lane & Milesi-Ferretti (2018)	Xu & Corbett (2020)	Garcia-Bernardo et al (2017)	IMF (2008)
Total		13	22	27	10	29	46
Andorra	AD			X			X
Anguilla	AI					X	X
Antigua and Barbuda	AG						X
Aruba	AW						X
Australia	AU						
Bahamas	BS	X	X	X		X	X
Bahrain	BH	X	X	X			X
Barbados	BB		X	X			X
Belgium	BE			X			
Belize	BZ					X	X
Bermuda	BM	X	X	X		X	X
British Virgin Islands	VG			X		X	X
Cayman Islands	KY	X	X	X	X	X	X
China	CN				X		
Chinese Taipei	TW					X	
Cook Islands	CK						X
Costa Rica	CR						X
Curaçao (AN to 2010)[1]	CW	X	X	X		X	X
Cyprus	CY		X	X		X	X
Dominica	DM						X
France	FR				X		
Germany	DE				X		
Gibraltar	GI			X		X	X
Grenada	GD						X
Guernsey	GG	X	X	X			X
Guyana	GY					X	
Hong Kong SAR	HK	X	X	X		X	X
Ireland	IE		X	X		X	X
Isle of Man	IM	X	X	X			X
Italy	IT						
Japan	JP				X		
Jersey	JE	X	X	X		X	X
Labuan (Malaysia)	MY						X
Latvia	LV		X				
Lebanon	LB						X
Liberia	LR					X	
Liechtenstein	LI					X	X

Country	ISO	Financial sector characteristics			Network characteristics		Mix of characteristics
		Kintzler et al (2019)	Zoromé (2007)	Lane & Milesi-Ferretti (2018)	Xu & Corbett (2020)	Garcia-Bernardo et al (2017)	IMF (2008)
Luxembourg	LU	X	X	X	X	X	X
Macao SAR	MO	X		X			X
Malta	MT		X	X		X	X
Marshall Islands	MH					X	X
Mauritius	MU		X	X		X	X
Monaco	MC					X	X
Montserrat	MS						X
Nauru	NR					X	X
Netherlands	NL			X	X	X	
Niue	NU						X
Palau	PW						X
Panama	PA		X	X			X
Samoa	WS					X	X
San Marino	SM			X			
Seychelles	SC					X	X
Singapore	SG	X	X	X		X	X
Spain	ES						
St Kitts & Nevis	KN						X
St Lucia	LC						X
St Vincent & Granadines	VC					X	X
Switzerland	CH	X	X	X	X	X	X
Turks & Caicos Islands	TC			X			X
United Kingdom	GB		X	X	X	X	
United States	US				X		
Uruguay	UY		X				
Vanuatu	VU		X				X

[1] Curaçao (CW) is one of the successor countries to the Netherlands Antilles (AN), which dissolved at end-2010.

Annex C Using LBS to adjust IIP data

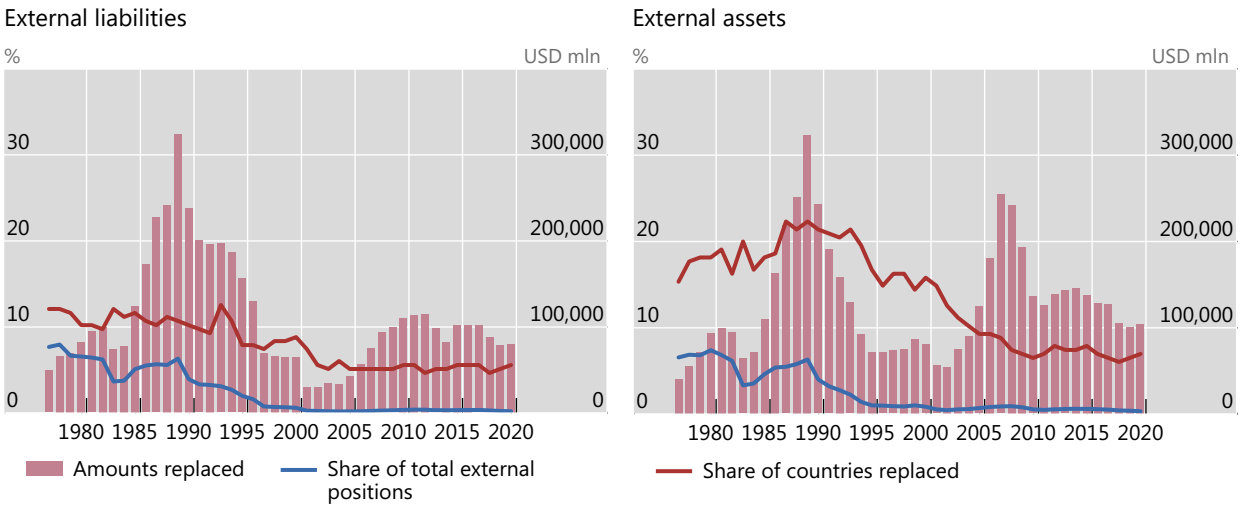
A country's international investment position (IIP) shows, for a given point in time, the outstanding value of all resident sectors' financial assets and liabilities towards all non-residents. Our main source for IIP data is the External Wealth of Nations dataset assembled by Lane and Milesi-Ferretti (2018). However, we replace IIP data when they are smaller than the BIS locational banking statistics (LBS). We also use LBS in years where IIP estimates are not available.

The LBS capture a subset of the IIP: residents' positions towards non-resident banks. The LBS mostly comprise loans and deposits (included in the "other investment" category of the IIP) but also include portfolio investment and derivatives. As of 2020 the LBS were reported to the BIS by banks in 48 countries and captured about 94% of all banks' cross-border business (BIS (2020)).

In principle, IIP data should always be larger than estimates of external assets and liabilities derived from the LBS because the former cover all sectors whereas the latter focus on banks. In practice, data derived from the LBS and other creditor sources, such as CPIS, are sometimes more comprehensive. For example, for Barbados and the Marshall Islands, the metadata to the EWN dataset explain that national data largely exclude the positions of entities that engage mostly with non-residents.

Data replaced by the LBS account for a small share of aggregate external assets and liabilities but a higher share of countries (Graph A1). Replacements are highest in the 1970s and 1980s. A higher share of assets is replaced than liabilities. For assets, data are replaced for reasons of both quality and availability, whereas for liabilities the main reason is availability.

Adjustments to international investment positions — Graph A1



Sources: BIS locational banking statistics; Lane and Milesi-Ferretti (2018), updated; authors' calculations.

Annex D Adjusted boxplot

The standard boxplot first popularised by Tukey (1977) visually summarises a distribution using five elements: the median; hinges equal to the first and third quartiles Q_1 and Q_3; thresholds that lie 1.5 times the interquartile range (IQR) above and below the hinges; whiskers that connect the hinges to the thresholds; and the potential outliers.[7] Tukey's boxplot identifies outliers as observations that fall above or below the thresholds given by equation (9):

$$[Q_1 - 1.5\,IQR\,;\, Q_3 + 1.5\,IQR] \qquad (9)$$

Hubert and Vandervieren (2008) adjust the standard boxplot for skewed distributions by incorporating the concept of the medcouple (*MC*). The medcouple is a measure of skewness introduced by Brys, Hubert and Struyf (2003) and is a more robust alternative to the standard skewness coefficient. The medcouple is the median of all possible quantile skewness measures. As shown in equation (10), it is defined as the median of the function $h(x_i, x_j)$, where Q_2 is the sample median, x_j are observations above the median, and x_i are observations below the median. *MC* takes a positive value for a right skewed distribution and a negative value for a left-skewed one.

$$MC = median_{x_{i \le Q_2 \le x_j}}\, h(x_i, x_j) \quad \text{where } h(x_i, x_j) = \frac{(x_j - Q_2) - (Q_2 - x_i)}{x_j - x_i} \qquad (10)$$

Hubert and Vandervieren (2008) incorporate the *MC* into the calculation of the boxplot's thresholds, replacing equation (9) with (11):

$$\begin{cases} [Q_1 - 1.5e^{-4MC} IQR;\, Q_3 + 1.5e^{3MC} IQR] & if\ MC \geq 0 \\ [Q_1 - 1.5e^{-3MC} IQR;\, Q_3 + 1.5e^{4MC} IQR] & if\ MC < 0 \end{cases} \qquad (11)$$

The choice of parameters 3 and 4 was derived by calibrating the threshold such that the expected percentage of outliers is close to 0.7%, which is a common cut-off for symmetric distributions. Hubert and Vandervieren (2008) did this calibration by fitting a broad range of symmetric and skewed distributions and restricting the medcouple to be less than 0.6.

By accounting for the skewness of the distribution, the adjusted boxplot method extends the length of the upper whisker in the case of a right-skewed distribution and the lower whisker for a left-skewed distribution. At the same time, it shortens the length of the whisker at the opposite end of the distribution. This shifts the length of the whiskers in the direction of the longest tail of the distribution and reduces the number of observations identified as outliers compared to the standard boxplot method.

[7] The reason behind the choice of the constant 1.5 is that, for a standard normal distribution with mean $\mu = 0$ and standard deviation $\sigma = 1$, the thresholds given by equation (9) capture observations falling within approximately 3 standard deviations of the mean and covering about 99.3% of the data. In other words, in the case of a normal distribution, the constant 1.5 is calibrated such that an observation has approximately a 0.7% chance of falling beyond the thresholds and being identified as an outlier. If the distribution is skewed, then this percentage is higher.

Annex E Countries identified as cross-border financial centres

		Identified as a XFC based on the intermediation ratio $XFIGDP$				Identified as a XFC based on the detrended measure δXFI			
		1977-1994[1]	1995-2020[2]	2020	2020 $XFIGDP$	1977-1994[1]	1995-2020[2]	2020	2020 δXFI
Bahamas	BS	18	26	X	29.8	18	19		3.3
Bahrain	BH	18	10		3.3	15	–		1.2
Barbados	BB	–	1		5.2	–	–		1.6
Belgium	BE	3	–		4.5	–	–		1.5
Bermuda	BM	18	26	X	188.2	–	20	X	5.2
British Virgin Isl.	VG	18	26	X	1,497.1	18	26	X	7.2
Cayman Islands	KY	18	26	X	980.1	18	26	X	6.8
Curaçao[3]	CW	18	26	X	40.2	18	24		3.6
Cyprus	CY	–	13	X	25.7	–	–		3.2
Gibraltar	GI	–	22		4.1	–	4		1.3
Guernsey	GG	–	20	X	78.2	–	20	X	4.3
Hong Kong	HK	16	18	X	11.8	–	–		2.5
Ireland	IE	3	23	X	21.6	–	–		3.1
Isle of Man	IM	–	20	X	17.5	–	–		2.8
Jersey	JE	–	20	X	123.2	–	20	X	4.8
Lebanon	LB	12	–		2.2	–	–		0.8
Liberia	LR	18	15		4.0	6	5		1.3
Liechtenstein	LI	10	–		4.0	–	–		1.3
Luxembourg	LU	11	26	X	182.7	6	26	X	5.2
Malta	MT	3	13	X	21.1	–	–		3.0
Marshall Islands	MH	–	17	X	73.0	–	15	X	4.2
Mauritius	MU	–	12	X	43.4	–	3		3.7
Nauru	NR	–	1		0.6	–	–		-0.6
Netherlands	NL	–	8	X	11.3	–	–		2.4
Panama	PA	18	2		1.2	1	–		0.2
Samoa	WS	–	1		6.6	–	–		1.8
San Marino	SM	2	4		0.7	–	–		-0.4
Seychelles	SC	4	–		5.7	–	–		1.7
Singapore	SG	16	8		10.5	–	–		2.4
Switzerland	CH	3	–		7.1	–	–		2.0
United Kingdom	GB	3	–		6.2	–	–		1.9
Vanuatu	VU	15	2		1.6	1	–		0.4

[1] Total number of years the country was identified as a XFC over the 1977-1994 period. [2] Total number of years the country was identified as a XFC over the 1995-2020 period. [3] For 1977-2010, data for Curaçao refer to Netherlands Antilles.

Annex F Countries identified as cross-border banking centres

		Identified as a XBC based on the intermediation ratio $XBIGDP$				Identified as XBC based on the detrended measure δXBI			
		1977-1994[1]	1995-2020[2]	2020	2020 $XBIGDP$	1981-1994[1]	1995-2020[2]	2020	2020 δXBI
Andorra	AD	2	–		0.4	2	–		2.5
Bahamas	BS	18	26	X	6.6	18	26	X	5.2
Bahrain	BH	18	17		0.9	18	10		3.1
Barbados	BB	2	26	X	3.9	–	24	X	4.7
Belgium	BE	17	4		0.4	–	–		2.1
Bermuda	BM	17	15		0.3	2	3		2.1
British Virgin Isl.	VG	18	26	X	1.7	18	26	X	4.0
Cayman Islands	KY	18	26	X	59.7	18	26	X	7.5
Macao SAR	MO	1	5	X	2.6	–	1	X	4.2
Curaçao[3]	CW	18	25		0.5	18	22		2.7
Cyprus	CY	–	1		0.1	–	–		1.0
Gibraltar	GI	–	15		0.6	–	14		2.9
Guernsey	GG	–	20	X	15.8	–	20	X	6.2
Hong Kong	HK	17	17	X	1.9	9	–		3.7
Iceland	IS	–	1		0.0	–	–		-0.5
Ireland	IE	–	3		0.7	–	–		2.6
Isle of Man	IM	–	18		0.8	–	13		3.1
Jersey	JE	–	20	X	11.1	–	20	X	5.8
Kiribati	KI	1	3		0.5	–	–		2.9
Liberia	LR	5	4		0.0	3	4		-2.1
Liechtenstein	LI	–	3		0.7	–	–		3.0
Luxembourg	LU	12	26	X	5.7	12	26	X	4.9
Malta	MT	–	1		0.2	–	–		1.6
Marshall Islands	MH	–	7		0.2	–	5		1.9
Nauru	NR	–	1		-	–	1		-
Panama	PA	17	4		0.2	8	–		1.4
São Tomé & Pr.	ST	1	–		0.0	–	–		-1.7
Singapore	SG	18	24	X	1.7	14	8		3.5
St. Helena	SH	1	1		0.0	–	1		-0.1
St. Vincent & Gr.	VC	–	1		0.1	–	–		1.5
Switzerland	CH	–	11		0.6	–	–		2.5
Turks & Caicos	TC	1	–		0.1	–	–		1.0
Tuvalu	TV	1	1		0.5	1	–		3.1
United Kingdom	GB	5	13	X	1.0	–	–		2.9
Vanuatu	VU	16	7		0.0	13	7		-1.0

[1] Total number of years the country was identified as a XBC over the 1977-1994 period. [2] Total number of years the country was identified as a XBC over the 1995-2020 period. [3] For 1977-2010, data for Curaçao refer to Netherlands Antilles.

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