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Identification of global systemically important stock exchanges

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Abstract
Research background: Increased regulations reducing systemic risk are essentially underpinned by the understanding of the global nature and sources of instability of the financial system. In the economic literature, there are many arguments presented by critical supporters and opponents of measuring and reporting global systemically important entities.
Purpose of the article: In response to the requirements of regulators, the article seeks to identify systematically important regulated stock markets for selected global stock exchanges by developing a composite ratio. Additionally, it provides empirical evidence concerning their risk exploration.
Methods: The proposed method uses weighted average values of indicators grouped in four categories: (1) market size, (2) cross-jurisdictional activity and interconnectedness, (3) substitutability, (4) complexity. The research covers stock exchanges, reported to WFE, spanning the period 2008–2017.
Findings & Value added: The study finds that the problem of systemic risk on global stock exchanges is growing despite numerous prudential regulations. In order to obtain a more complete assessment of market systemic sensitivity, regulators should take into account a wider range of indicators and calculations such as cross-jurisdictional activity and market complexity.

Introduction

The Basel Committee on Banking Supervision (BIS, 2013) has developed a procedure for identifying global systemically important banks (G-SIB) that includes the calculation of a total indicator based on the following 5 categories: (1) cross-jurisdictional activity, (2) size (total exposures used to compute the leverage ratio), (3) interconnectedness (including the size of the securities portfolio), (4) substitutability (the function of financial infrastructure, in particular the amount of negotiable financial instruments under custody), (5) complexity (including the notional amount of OTC derivatives with the bank as a counterparty and the amount of trading and available-for-sale securities). The main macroprudential tool used for systemically important banks is the requirements for additional capital buffers (1–3.5% of risk-weighted assets). When determining the systemic importance of banking institutions, what equally matters is their securities and derivatives transactions. Hence, the introduction of systemic buffers may contribute to increased market stability. Based on the Basel Committee's proposal, the European Banking Authority (EBA, 2014) has devised a method for identifying systemically important banks in the EU (O-SII).

The FSB and IOSCO (2015) proposals to identify systemically important investment institutions on a global scale foresee that the activities of such entities holding assets of over USD 100 billion should be analysed in the following categories: (1) size (total consolidated balance sheet assets and off-balance sheet exposures); (2) interconnectedness (assets and liabilities in relation to other elements of the financial system, leverage); (3) substitutability (qualitative assessment of an investment firm's market share in various derivatives markets and ease of substitutability by other provider(s)); (4) complexity (notional amount of OTC derivatives and difficulty in resolving a firm); (5) cross-jurisdictional activities (value of cross-jurisdictional claims and liabilities, the number of jurisdictions in which a company operates, the value of assets or revenues in foreign jurisdictions).

We believe that the "complexity" category within the procedure should also comprise an additional indicator reflecting the level of algorithmic trading, including high frequency trading (which is a fairly common and significant source of instability at the current stage of market development). Moreover, the "substitutability" category should incorporate an indicator (which may be binary) for entities that systematically internalise transactions (in an organised and systematic manner conclude many transactions on their own account, executing client orders outside a regulated market) and an assessment of capacities of other entities performing these opera-

tions. It is also necessary to develop identification procedures for systemically important investment funds (NBNI G-SIFI), in order to establish additional capital buffers, taking into account FSB and IOSCO recommendations (2015).

Following the report by the International Monetary Fund (IMF *et al*., 2009), which defines fundamental approaches to assessing the systemic importance of financial markets, IOSCO experts (Bijkerk *et al*., 2012) described in detail the impact of systemic risk in capital markets, yet now no uniform method exists for identifying systematically important financial markets. The study was preceded by literature studies (theoretical and empirical), which formed the basis for us to recognise a significant gap in this respect.

Our primary objective is to identify systematically important regulated stock markets for selected global stock exchanges by developing a composite ratio and, in the second step, to provide empirical evidence concerning systemically important stock exchanges and their risk exploration This task was accomplished through intermediate objectives including:

– developing and estimating components of the main ratio such as: size, financial interconnectedness, substitutability and complexity of the financial market;
– assigning individual regulated markets to one of four groups that were created on the basis of quartiles of index values.

In order to implement prudential tools, methods for identifying systematically important institutions (banks, insurance companies, investment firms, etc.), infrastructure and markets should be devised. On that ground, the following composite ratio referring to the systemic character of regulated stock markets considers comprehensively four categories: i/ market size; ii/ cross-jurisdictional activity and interconnectedness; iii/ substitutability; iv/ complexity. The proposed ratio is a major source of information about systemically important stock markets and a basis for identifying more or less systemically dangerous markets.

Our paper contributes to the existing literature in several ways. First, our study is one of the few contributions to date that has attempted to quantify the existence of systematically important regulated stock markets for selected global exchanges on the basis of four categories. Second, our approach is different in that it examines banking sector valuations in reaction to the regulatory changes concerning SIFIs. We test new evidence of a significant risk contribution from major stock markets over the post-crisis period 2008–2017, using a new methodology. To the best of our knowledge, the study is the first to address such an issue. Third, the results would help international investors intending to diversify investment to as-

sess the risks and build optimal portfolios. Finally, our study can be applied to portfolio and risk management for investors who monitor risk across capital markets. Moreover, supervision authorities and regulators could potentially find markets and instruments which are the most dangerous to the stability of the financial system.

The article consists of five parts. In the first part, we present the research background of the issue of identification of global systemically important stock exchanges. As the economic literature contains many arguments presented by critical supporters and opponents of measuring and reporting global systemically important entities, we make a literature review and justify how our research contributes to the existing literature in the second part of paper. A description of the research method based on calculation of the composite ratio of systemically important financial instruments markets as well as data characteristics are presented in the third part. The fourth part reports results where systemically important stock exchanges were identified. Finally, we emphasise our findings and present conclusions for investors and regulators.

Literature review and hypotheses

The passage of the Dodd Frank Wall Street Reform, as a legislative response to the financial crisis, marked a significant activity in the financial regulation. Specifically, it imposes more stringent regulations on systemically important financial institutions and their activities to reduce systemic risk. Key empirical studies investigating the prudential regulation in the financial market are aimed at identifying too-big-to-fail (TBTF) financial institutions (Ryan, 2008; Kroszner & Strahan, 2011; Barth *et al*., 2012). However, there is a lack of research on the systematic significance of stock markets. We contribute to the literature on macroprudential financial regulation by examining stock exchange market reactions. Based on the analysis of recommendations by FSB, IMF and BIS (2011), FSB, IMF and BIS (2016) and research works performed by Galati and Moessner (2011) and Schoenmaker (2014), macroprudential policy in the market for negotiable financial instruments can be defined as the use of prudential tools to mitigate systemic risk in order to achieve stability (or minimise losses ensuing from the instability of the market and the whole financial system).

Reports from international organisations such as FSB *et al*. (2016), CGFS (2016), ESRB (2013) and the results of research carried out by Galati and Moessner (2011), Claessens (2014), and Schoenmaker (2014) adopt the following macroprudential policy objectives:

1. the main objective is to ensure market stability as part of maintaining the stability of the whole financial system;
2. intermediate objectives: (a) to increase resilience (flexibility) of the market and its participants to adverse shocks; (b) to reduce (smooth) excessive cyclicality (in relation to price dynamics, liquidity, stock issue value, number of open positions, etc.) of stock, debt securities and derivatives markets, consequently minimising the probability of market booms (including bubbles) and busts; (c) to reduce the sensitivity of systemically important markets, market participants (banks, investment firms, other shadow banking institutions) and infrastructure (depository and settlement systems);
3. operational objectives are set indirectly and quantified to verify the effectiveness of macroprudential tools. For example, the objectives of cyclicality smoothing comprise the objectives of controlling the behaviour of market participants, etc.

On the basis of literature review, the following two groups of macroprudential instruments can be specified to achieve the objectives:

1. direct, which *per se* concern the market;
2. indirect, which cover the regulation of market participants' activity by establishing stringent standards, additional capital buffers, etc.

Furthermore, instruments can be divided according to their target direction:

1. temporal – smoothing market cyclicality and increasing the resilience of participants to accumulated imbalances;
2. cross-sectoral – reducing the destabilising role of excessive interconnectedness between markets and their participants.

The global activity of a financial institution is generally measured by its cross-jurisdictional claims and liabilities. The Basel Committee also proposes measuring non-domestic revenue as an aid. Generally, financial institutions conducting global operations are presumed to pose a particular threat to the stability of the global financial system in comparison to those active only in national markets. Globally active banks are often larger than domestic ones, and — through the exposure ensuing from foreign funding — can generate a broader supranational channel of systemic risk contagion.

On the other hand, the measurement of global banking activity is a typical example of how the identification of an institution's systemic importance should not be used for comparative purposes by regulatory authorities. The reason is that assigning regulatory burdens to cross-jurisdictional claims and liabilities involves the risk of unintended side effects. If, due to SIFI regulations, globally operating banks generate higher marginal costs in their cross-jurisdictional activities than their local competitors, they will be

automatically less competitive. To counteract such practices, the EU has introduced the idea of a single market for financial services. Also in the global context, it is not clear why a system that provides incentives to limit cross-jurisdictional activity will be more stable than one that favours geographical diversification. Čihák *et al.* (2011) and Mayer *et al.* (2010) argue that systemic resilience increases with growing cross-jurisdictional interconnectedness, at least up to a point. After having reached the optimal point, resilience decreases again until the system of financial institutions restores its specific "elasticity".

Gravelle *et al*. (2013) propose a set of market-based measures of the systemic importance of six Canadian banks and find that the risk contribution to the domestic banking sector, named "home bias", is bigger than a cross-country risk contribution. They also confirm that the size of a financial institution is not the main and important issue in measuring systemically the importance in the banking sector. Strong interconnectedness of the Canadian banking sector with the U.S. and the euro area resulted in a major risk contribution to the domestic sector, larger than from Asian banks. Following that study, we assume the hypothesis:

H1: *The size of a financial stock market is not a proxy of systemic importance*.

Systemically important capital markets and their significance for global risk are the subject of numerous studies and discussions. Fang *et al*. (2017) used the Asymmetric Dynamic Conditional Correlation (ADCC) method with Delta Conditional Value at Risk (ΔCoVaR) to compare the systemic importance of G7 (Canada, France, Germany, Italy, the United Kingdom, and the US) and BRICS (Brazil, Russia, India, China and South Africa) stock markets. Their research showed that more developed markets contribute more to the global systemic risk than developing countries. Morales and Andreosso-O'Callaghan (2012) proved that Asian stock markets had not been affected by systemic risk during the global financial crisis initiated in the U.S. market. The latter used the correlation of return rates proposed by Forbes and Rigobon (2002).

In order to identify the systemic importance of financial markets or institutions, various risk measures were suggested, such as CoVar calculating the risk contributed by a selected financial institution to the entire system (Adrian & Brunnermeier, 2011). In turn, Huang *et al*. (2009) built integrated systemic importance indicators considering: size, leverage, and interconnectedness. Another approach relies on verification of interconnectedness between institutions and financial markets. In this area, detailed re-

search was carried out on high frequency data, a substantial number of individual entities, or for individual countries including: Boss *et al*. (2004) and Puhr *et al*. (2012) in Austria; Degryse and Nguyen (2007) in Belgium; Craig and von Peter (2010) in Germany; Iori *et al*. (2008), Fricke and Lux (2015) in Italy; In 'T Veld and van Lelyveld, (2012) in the Netherlands and Langfield *et al*. (2014) in the UK.

Fang *et al*. (2018) present the overall systemic risk of Chinese financial institutions and show that a bank's risk can be affected by its connectedness with other institutions. They also emphasise that from June 2014 to June 2016 the number of connections between Chinese banks increased significantly. Many studies are based on growing risk of contagion (Roengpitya & Rungcharoenkitkul, 2016; López-Espinosa *et al*., 2012). Hong *et al*. (2004) provide an empirical study on the spillovers of downside market risk among A, B, and H shares in the Chinese stock exchange. Yu *et al*. (2018) provide an empirical study on the risk contribution of the Chinese stock market to four stock market indices (the FTSE 100 of the UK, the DAX 30 of Germany, the S&P 500 of the U.S., and the Nikkei 225 of Japan, as representative developed markets in Europe, North America and Asia) and find that the interdependence between the global stock market and China results from geographic location.

To summarise, we test the second hypothesis that:

H2: *Despite numerous prudential regulations, the problem of systemic risk on global stock exchanges is growing.*

Research methodology

Taking into account the works analysed above, we will conduct research on the identification of systemically important regulated stock markets at the global level under the indicator-based measurement approach developed by the Basel Committee on Banking Supervision.

Considering limited publicly available data, we suggest that the composite ratio (SIFIMR — systemically important financial instruments markets ratio) for *i*-period (year) in *j*-country be computed as weighted average values of indicators grouped in four categories:

$$SIFIMR_{ij} = \frac{S_{ij}+CI_{ij}+SbS_{ij}+C_{ij}}{4} \quad (1)$$

A detailed description of the indicators in individual categories is provided in Table 1.

Domestic market capitalisation is calculated as at year-end (December). The total stock exchange turnover and turnover of foreign stocks are calculated as the sum of monthly trade value based on the electronic order book (EOB) in a given year.

The total number of derivatives contracts traded on the trading venue (in a given year) include data regarding stock options, single stocks futures, stock index options and futures, ETF options and futures, interest rate options and futures, commodity options and futures, currency options and futures.

All data are calculated in an annual format. The source of data for this study (more than 80 trading venues) is the World Federation of Exchanges (WFE).

To calculate the score for a given indicator, we use the approach of the Basel Committee on Banking Supervision (BIS, 2014) — the reported value for that indicator is divided by the corresponding sample total, and the resulting value is then expressed in basis points (bps):

$$\frac{Trading\ venue\ indicator\ (in\ USD)}{Sample\ total\ (in\ USD)} \times 10000 = Indicator\ score\ (bps) \quad (2)$$

The sample total (denominator) is calculated as the sum of indicator values for all trading venues in the statistical base of the World Federation of Exchanges in a given year. The maximum value of the composite ratio is 10,000.

Systemically important stock trading venues were identified (in each year) following k-means clustering pursuant to Lloyd's algorithm. The classification quality was determined by using the Rand index based on replication. This involves classification of a set of objects on the basis of two samples drawn from a particular data set. Subsequently, the results were assessed for compatibility (Walesiak & Gatnar, 2009). Systematically important trading venues included institutions clustered in the group with the largest composite ratio values.

Results

Systemically important stock exchanges were identified based on the analysis of annual data over 10 years (2008–2017) for all stock exchanges with information available in the WFE's statistical reports.

Following the cluster analysis (Table 2), the Rand index revealed 4 groups in most years (5 groups in 2012–2013 and 2017). For all years under analysis, the Rand index was more than 0.7, indicating a strong class structure.

The most numerous groups (IV and V) encompass stock exchanges with the smallest composite ratios (about 66% of all exchanges in 2017). As regards group I, 3 exchanges identified as systemically important (the highest composite ratios) can be observed in most years under examination.

In 2008–2009, only the US NYSE was systemically important in group I (Table 3) with a high composite ratio compared to other institutions (Table 3). Notably, 2008 saw this ratio reach 2,123.9 bps of its maximum value (10,000), which proves a very strong role of that exchange at the international level. For comparison, the 2016 aggregate score for the JP Morgan Chase bank (the largest G-SIB) was only 467.2 bps.

Over the next years, the composite ratio for NYSE dropped to its minimum value in 2017.

Systemically important stock exchanges also included the US Nasdaq and London Stock Exchange Group (LSE Group), which was the biggest stock exchange in the world in 2017 according to the composite ratio value.

In 2015, the Chinese Shenzhen Stock Exchange joined the club due to its significant role in the organisation of trade in securities of investment funds (the ratio amounted to 6,364 bps in 2015). In the following years, the Shenzhen Stock Exchange, however, ceased to be identified as globally systemically important because the Chinese regulations do not permit trade in foreign securities. Hence, the sub-index for cross-jurisdictional activity is zero and significantly reduces the composite ratio.

The average total value of the composite ratio (in 2010–2018) for global systemically important stock exchanges amounted to 36.4% of its maximum value, reflecting high global concentration of trade in financial instruments.

The mean difference between the maximum value of the composite ratio for stock exchanges in group II and the minimum value for group I in the study period (except in 2008–2009) was 390 bps (the smallest difference was recorded in 2015 — 162 bps). Therefore, it could be predicted that the number of systemically important markets is unlikely to change in the coming years. However, in 2017, the BATS trading venue was taken over by the CBOE (Chicago Board Options Exchange), a U.S. derivatives market, and, based on the data for 2018, the new comprehensive cross-jurisdictional trading venue can be classified as systemically important.

Group II is marked by greater volatility as regards individual stock exchanges (Table 4) except for 2007–2008. Only four out of fourteen trading

venues (SIX Swiss Exchange, BATS Chi-x Europe, Japan Exchange Group Inc., Luxembourg Stock Exchange) qualified for group II for more than 5 years. For the Shenzhen Stock Exchange and Deutsche Boerse AG, the range of the composite ratio exceeded 600 bps.

As regards the increase in importance, we can distinguish the Chinese Shenzhen Stock Exchange, whose composite ratio rose by 319 bps in the study period. On the other hand, the largest decrease in the composite ratio was noted for Deutsche Boerse AG — 565.5 bps.

Systemically important markets in particular categories are presented in Tables 5–8.

In the "size" category (Table 5), where size was determined by market capitalisation and turnover, the NYSE and Nasdaq were systemically important in most analysed years. In 2008, almost 50% of market capitalisation and global stock turnover was concentrated only on these two stock exchanges. Yet, recent years have witnessed a decrease in the total value of the sub-index for the group of systemically important markets in this category — in 2017, it stood at approximately 35% of the maximum value.

In the "cross-jurisdictional activity and interconnectedness" category (Table 6), greater volatility was spotted for the identified global systemically important markets. In 2008–2009, the US NYSE and Nasdaq and the SIX Swiss Exchange dominated. Since 2010, however, the LSE Group and BATS Europe (the U.S. market operator's unit) have been identified as the largest systemic stock exchanges, the latter having been established in the EU in 2007 with the legal status of an MTF (multilateral trading facility). Since 2013, the BATS has been a regulated market. That trade operator is registered in the United Kingdom, but works as a pan-European concentrator of turnover of the most liquid shares from various EU countries.

In 2016–2017, we can observe a rise in the number of stock exchanges as systemic institutions in this category. The current situation reflects the intensified globalisation in capital markets, which makes markets more fragile in their response to negative market shocks. About 70% of the turnover of foreign securities is concentrated in Europe (2017). On the one hand, this is evidence of greater financial integration, while making systemic risk is more likely to materialise across jurisdictions on the other.

In the "substitutability" category (Table 7), the Luxembourg Stock Exchange was identified as a systemically important market throughout the entire time horizon under study since approximately 30% (average value for 2008–2017) of all bond issues took place there globally.

Systemically important markets in this category included 3–4 stock exchanges in almost all the years studied. In 2017, however, 7 institutions were already identified as systemically important in global terms. In partic-

ular, we can see an increased role of stock exchanges in the Asia-Pacific region (except for Japan) as institutions where to issue stocks and bonds. Only on Chinese stock exchanges (Shenzhen Stock Exchange, Shanghai Stock Exchange, Hong Kong Exchanges and Clearing), stock issue transactions amounted to about 32% of total issues in 2017 whereas they stood as low as at around 10% in 2008.

In the "complexity" category (Table 8), the US NYSE and Nasdaq and the BME Spanish Exchanges qualified for the group of global systemically important trading venues throughout most of the time horizon under study.

The BME Spanish Exchanges was identified as a systemically important institution because its bond turnover was 39% (average value in 2008–2017) of the total global bond turnover on stock exchanges.

In addition to being stock trading venues, the NYSE and Nasdaq are systemically important in view of their complexity as they play a considerable global role in terms of turnover of investment fund units, ETFs and derivatives (especially futures, stock options and ETFs).

As concerns derivatives, it should be noted that specialised exchanges play an important role for some contracts in this segment of the financial instruments market. In 2017, in particular, 53.6% of total numbers of interest rate options and futures contracts were concluded on the Chicago Mercantile Exchange (CME). This figure was 20% on the CME and 24% on the Shanghai Futures Exchange for commodity derivatives.

For the last two years (2016–2017), global systemically important markets in the "complexity" category also comprised the LSE Group, which noted a large share of the global bond turnover (in 2017 — 39.4%, in 2016 — 36.2%). Together with the BME Spanish Exchanges, the share of these two European exchanges was around 60% of the total bond turnover worldwide in those years. Yet, as regards trade in bonds, it must be said that most transactions are concluded in over-the-counter markets.

Discussion

Our study contributes to current literature in the following two aspects. Firstly, we provide a new perspective on research, regarding systemically important markets and financial instruments of different stock markets on a global scale. Previous research emphasises the contagion effect among individual markets (Degryse & Nguyen, 2007; Craig & von Peter, 2010; Hong, 2004). Secondly, to the best of our knowledge this is the first study that employs a composite ratio measure and cluster analysis to evaluate systemic risk contributions of stock markets.

What is significant for ensuring effective regulation of systemically important markets is coordinated actions of regulatory authorities in various countries, including an assessment of the impact of potential cross-border mergers and acquisitions of market operators on systemic stability. The finding is partially consistent with the study by Fang *et al.* (2017), who suggest that developed markets contribute relatively more to global systemic risk than emerging markets. Similarly to the empirical results obtained by Kao *et al.* (2018), we stress that the systemic risk that started during the subprime mortgage crisis is a complex issue, still exists and is not limited to a single market.

Our results have practical implications for academia and financial regulators who monitor systemic risks. However, to better understand market risk contributions, special types of tools based on the Asymmetric Dynamic Conditional Correlation (ADCC) and the Delta Conditional Value at Risk (ΔCVaR) should be applied. There are also some research limitations like: limited publicly available data concerning high frequency trading on the venues, shares of foreign investors in total stock exchange turnover, or new issues of stocks of foreign issuers. Furthermore, it is worth considering the introduction of additional capital buffers to cover systemic risk and the development of recovery and resolution plans for systemically important markets in financial instruments. These findings also contribute relevant evidence to the debate on the role of systemically important markets in the recent crisis. They suggest that the lack of a comprehensive approach from regulators as regards impending systemic risk during the lead-up to the crisis imposed limitations on existing regulation and meant a potential inability to respond to escalating distress. Our research is also a way forward to wider development in the following areas: new macroprudential instruments for systemically important trading venues identified in our approach and empirical study on the identification of systemically important trading venues in the regional dimension (on the basis of WFE classification — Americas, Asia-Pacific, Europe-Africa-Middle East), or the development of a composite ratio to identify systemically important specialised regulated markets and multilateral trading facilities for derivatives and bonds.

Conclusions

In order to identify systemically important markets, macroprudential tools should be developed, in particular along the lines of MiFID II requirements for regulated markets stating that such markets must have effective systems, procedures and arrangements to guarantee that their trading systems

are resilient. Their sufficient capacity should ensure dealing with peak order and message volumes and orderly trading under conditions of severe market stress (European Parliament and European Council, 2014).

This paper proposes a composite ratio as a tool to measure the systemic importance of systematically important regulated stock markets for selected global stock exchanges. The presented method uses weighted average values of indicators grouped in four categories: (1) market size, (2) cross-jurisdictional activity and interconnectedness, (3) substitutability, (4) complexity. We test new evidence of significant risk contribution from major stock markets over the post-crisis period 2008–2017.

Our hypothesis that the size of a financial stock market is not a proxy of systemic importance is verified positively.

The study has proved that in order to obtain a more complete assessment of market systemic sensitivity that would take into account a wider range of indicators, regulators should develop adequate data sets for all trading venues, not only for regulated stock markets. In particular, the following indicators may be added to the calculations:

– cross-jurisdictional activity – the share of foreign investors in turnover, provision of services in the territory of other countries;
– complexity – high frequency trading as a share of market turnover, short sales as a share of market turnover.

As highlighted by the results of this study, systemic risk of major stock markets has not diminished, as proved by H2 hypothesis that the problem of systemic risk on global stock exchanges is growing despite numerous prudential regulations.

To summarise, requirements for systemically important markets (trading venues) and financial instruments (SIMF) constitute a cross-sectoral macroprudential tool which should be aimed at reducing the possible negative impact of excessive interconnectedness between markets and market participants. This tool is worth applying based on the identification of systemically important markets in the context of trading venues (as defined in MiFID II), especially regulated markets, multilateral trading facilities, and organised trading facilities.

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Annex

Table 1. Indicators for identifying systemically important regulated stock markets

Category and weighting	Individual indicator	Indicator weighting
Size (S) – 25%	Domestic market capitalisation	12.5%
	Total stock exchange turnover	12.5%
Cross-jurisdictional activity and interconnectedness (CI) – 25%	Turnover of foreign stocks	12,5%
	Turnover of foreign bonds	12.5%
Substitutability (SbS) – 25%	New issues of stocks on the trading venue	12.5%
	New issues of bonds on the trading venue	12.5%
Complexity (C) – 25%	Total turnover of investment funds securities	6.25%
	Total turnover of exchange-traded funds' securities (ETFs)	6.25%
	Total turnover of bonds	6.25%
	Total number of derivative contracts traded	6.25%

Table 2. Cluster analysis of data for trading venues

Year	Number of trading venues	Number of clusters	Rand coefficient	Number of trading venues in cluster (maximum value of composite ratio in cluster, bps.)				
				I	II	III	IV	V
2008	55	4	0.77	1 (2123.86)	4 (1045.42)	13 (336.78)	37 (122.11)	
2009	54	4	0.785	1 (1775.52)	2 (1108.53)	12 (549.96)	39(201.63)	
2010	56	4	0.828	3 (1575.34)	8 (568.84)	9 (265.42)	35 (96.29)	
2011	58	4	0.841	3 (1469.47)	9 (630.89)	9 (239.20)	36 (89.15)	
2012	58	5	0.833	3 (1433.77)	5 (654.22)	10 (323.01)	6 (159.17)	33 (49.15)
2013	64	5	0.852	3 (1483.46)	4 (659.67)	10 (351.24)	7 (151.33)	39 (49.32)
2014	83	4	0.874	3 (1405.66)	13 (616.75)	10 (206.25)	56 (56.17)	
2015	86	4	0.920	4 (1179.45)	9 (646.37)	10 (253.69)	62 (64.62)	
2016	84	4	0.898	3 (1244.34)	8 (694.90)	8 (305.64)	64 (93.25)	
2017	83	5	0.917	3 (1176.31)	8 (573.94)	7 (295.18)	9 (133.21)	55 (38.54)

Table 3. Global systemically important trading venues by composite ratio

Year	Number of trading venues	Trading venues	Score of composite ratio, bps.
2008	1	NYSE	2123.9
2009	3	NYSE	1775.5
2010	3	NYSE	1575.3
		Nasdaq	1087.5
		LSE Group	1075.4
2011	3	NYSE	1469.5
		LSE Group	1314.9
		Nasdaq	1146.1
2012	3	NYSE	1433.8
		Nasdaq	1151.4
		LSE Group	983.0
2013	3	NYSE	1483.5
		Nasdaq	1086.6
		LSE Group	1084.7
2014	3	NYSE	1405.7
		Nasdaq	1152.2
		LSE Group	906.9
2015	4	NYSE	1179.5
		Nasdaq	1063.4
		LSE Group	826.9
		Shenzhen Stock Exchange	809.1
2016	3	NYSE	1244.3
		LSE Group	1146.9
		Nasdaq	1002.5
2017	3	LSE Group	1176.3
		Nasdaq	1168.9
		NYSE	1163.4

Table 4. Group II statistics by composite ratio (2008–2017)

Trading venues	Number of years in cluster II	Score of composite ratio, bps.			Change of composite ratio value, bps.		
		mean	max	min	1 year	5 years	10 years
SIX Swiss Exchange	9	492.5	676.2	319.3	-28.2	-64.0	-275.2
BATS Chi-x Europe	8	552.5	659.7	189.4	-43.2	-85.7	-384.5
Japan Exchange Group Inc.	7	323.6	412.9	258.1	5.2	-21.9	96.8
Luxembourg Stock Exchange	7	367.1	453.6	314.4	-69.2	30.8	18.1
BME Spanish Exchanges	5	346.7	493.8	208.1	-23.6	-143.1	-114.4
Nasdaq Nordic Exchanges	5	297.5	449	170.5	17.4	-235.0	-72.5
Shanghai Stock Exchange	4	278.4	505.4	152.9	6.8	113.2	202.8
Shenzhen Stock Exchange	4	355.5	809.1	109.2	-245.6	221.2	340.1
Euronext	4	360.1	576.9	206.4	-90.5	224.6	157.9
Korea Exchange	4	285	328.2	231.4	-10.5	38.2	63.8
Deutsche Boerse AG	4	307	741	75.6	98.9	-114.5	-566.5
BATS Global Markets	2	197.2	359.8	14.3	-26.1	121.2	319.4
Hong Kong Exchanges and Clearing	2	245.1	323	162.8	46.6	50.5	114.6
National Stock Exchange of India Limited	1	192.2	260.9	122.1	30.9	64.9	138.9

Table 5. Global systemically important trading venues for the “size” category

Trading venue	Score, bps.	Trading venue	Score, bps.
2008		**2009**	
NYSE	2871	NYSE	2522
Nasdaq	1598	Nasdaq	1326
2010		**2011**	
NYSE	2417	NYSE	2353
		Nasdaq	1198
2012		**2013**	
NYSE	2366	NYSE	2373
Nasdaq	1204	Nasdaq	1163
2014		**2015**	
NYSE	2401	NYSE	2094
Nasdaq	1269	Shanghai Stock Exchange	1277
		Shenzhen Stock Exchange	1133
		Nasdaq	1093
2016		**2017**	
NYSE	2397	NYSE	2172
		Nasdaq	1273

Table 6. Global systemically important trading venues for the "cross-jurisdictional activity and interconnectedness" category

Trading venue	Score, bps.	Trading venue	Score, bps.
2008		**2009**	
SIX Swiss Exchange	2374	NYSE	1849
NYSE	2039	SIX Swiss Exchange	1689
Nasdaq	1565	BATS Chi-x Europe	1417
		Euronext	1160
		Nasdaq	1129
		LSE Group	1075
2010		**2011**	
BATS Chi-x Europe	2095	LSE Group	3306
LSE Group	1907	BATS Chi-x Europe	2322
NYSE	1366		
SIX Swiss Exchange	927		
2012		**2013**	
BATS Chi-x Europe	2427	BATS Chi-x Europe	2468
LSE Group	2045	LSE Group	1807
		SIX Swiss Exchange	1541
2014		**2015**	
SIX Swiss Exchange	2306	BATS Chi-x Europe	2392
LSE Group	1966	SIX Swiss Exchange	2039
BATS Chi-x Europe	1681		
2016		**2017**	
LSE Group	2346	LSE Group	2417
BATS Chi-x Europe	2316	BATS Chi-x Europe	2151
SIX Swiss Exchange	1423	Nasdaq	1307
Nasdaq	1209	SIX Swiss Exchange	1287
Euronext	1128	Euronext	1001
NYSE	968	NYSE	930

Table 7. Global systemically important trading venues for the "substitutability" category

Trading venue	Score, bps.	Trading venue	Score, bps.
2008		**2009**	
London Stock Exchange	1775	LSE Group	1995
Deutsche Boerse AG	1583	TMX Group	1633
NYSE	1431	Luxembourg Stock Exchange	1515
Luxembourg Stock Exchange	1334	NYSE	1321
2010		**2011**	
Luxembourg Stock Exchange	1434	Luxembourg Stock Exchange	1249
LSE Group	1395	LSE Group	968
NYSE	1036	NYSE	924
		Deutsche Boerse AG	757
2012		**2013**	
Luxembourg Stock Exchange	1802	LSE Group	1523
NYSE	995	Luxembourg Stock Exchange	1281
LSE Group	907	NYSE	1189

Table 7. Continued

Trading venue	Score, bps.	Trading venue	Score, bps.
2014		**2015**	
Luxembourg Stock Exchange	1410	Luxembourg Stock Exchange	1454
NYSE	971	LSE Group	1132
Hong Kong Exchanges and Clearing	812	Korea Exchange	813
LSE Group	777	Hong Kong Exchanges and Clearing	754
2016		**2017**	
Luxembourg Stock Exchange	1672	Luxembourg Stock Exchange	1393
		LSE Group	828
		Shenzhen Stock Exchange	644
		NYSE	620
		National Stock Exchange of India Limited	601
		Shanghai Stock Exchange	599
		Korea Exchange	595
		Hong Kong Exchanges and Clearing	575

Table 8. Global systemically important trading venues for the "complexity" category

Trading venue	Score, bps.	Trading venue	Score, bps.
2008		**2009**	
NYSE	2154	Nasdaq	1934
		NYSE	1410
		BME Spanish Exchanges	1116
2010		**2011**	
Nasdaq	2175	Nasdaq	2449
NYSE	1482	NYSE	1370
BME Spanish Exchanges	1161	BME Spanish Exchanges	1344
2012		**2013**	
Nasdaq	2399	Nasdaq	2242
NYSE	1289	NYSE	1354
BME Spanish Exchanges	1060	BME Spanish Exchanges	954
2014		**2015**	
Nasdaq	2147	Nasdaq	1720
NYSE	1290	Shenzhen Stock Exchange	1627
BME Spanish Exchanges	1129	NYSE	1032
		BME Spanish Exchanges	1023
2016		**2017**	
Nasdaq	1567	Nasdaq	2051
NYSE	974	LSE Group	1059
LSE Group	977	NYSE	933
Shenzhen Stock Exchange	918		
BME Spanish Exchanges	673		
BATS Global Markets (US)	650		
Japan Exchange Group Inc.	596		