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Dynamics of financial markets and transaction costs: A graph-based study

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In financial markets, trading patterns influence the behaviour of arbitrage, surveillance, risk management and pricing returns. The analysis of these patterns is important for defining policies in financial regulation as well as portfolios of international assets. Using financialization as a conceptual framework to understand the current trading patterns of financial markets, this work employs a market graph model for studying the stock indexes of geographically separated financial markets. By using an edge creation condition based on a transaction cost threshold, the resulting market graph features a strong connectivity, some traces of a power law in the degree distribution and an intensive presence of cliques. Furthermore, an inverse relation between transaction costs and maximal clique size is noticed. The market graph model also indicates that infrastructure, sustainability and commodity indexes from APEC, EU and NAFTA affect the behaviour of markets. As a result, the graph approach shows a consistent set of outcomes that mostly explain the financialization dynamics of markets.

1. Introduction

The increasing complexity of the financial networks requires a conceptual framework that combines aspects of information technologies, deregulation of economies and the “shareholder value paradigm” (Sokol, 2015). In this sense, financialization emerges as a relevant interdiciplinary concept to understand the current integration process of stock markets.

Financialization is essentially a spatial process that represents a key feature of contemporary capitalism and its corresponding dynamics (Cloke, 2013). An attractive research subject in financialization is the study of transaction patterns in geographically separated financial markets (Lagoarde-Segot, 2016). Such an attractiveness has mainly been a result of several recently-occurred changes in the financial sector, such as liberalization reforms, financial transaction velocity and speculative trading (Lapavitsas, 2013). With the exception of Lagoarde-Segot (2015), limited progress has been achieved on the

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study of financialization through empirical financial techniques. This work contributes to empirical finances by examining the relation between transaction costs (TCs) and the interaction of financial markets among diverse geographical conditions.

Several studies have investigated topics related to transmission of volatility (contagion) between markets (Barrett and Bellemare, 2011), the behaviour of series correlation during times of high uncertainty (Fulop and Lescourret, 2009) and the role of transaction costs (TCs) on the formation of financial networks (Nagurney, 2003). This last topic is specially important for the construction of international portfolios as well as for the understanding of asset trading relations in a sociopolitical context (Gai and Kapadia, 2010; Cloke, 2010, 2013).

Although there is general agreement that higher TCs affect expected returns and lower trading volumes, a disagreement in the literature regarding the magnitudes of these effects at a geographical level is noticeable. For example, Thapa and Poshakwale (2010) demonstrated that higher TCs lead to higher risk adjusted expected returns. As a result, these returns are highly sensitive to changes in TCs. Additionally, it is well known that investors seeking to maximize their net returns demand compensation for investing in securities with high TCs (Onnela et al., 2003). The value of these securities produces an increase over the rate of return (Baker and Jorgensen, 2012). Higher TCs also lead to longer average holding periods and lower trading volumes, since the higher expected returns offered by high transaction-cost securities attract investors with longer holding periods. As a result, a higher trading costs over a longer investment horizon is better repaid (Habermeier and Kirilenko, 2003).

A special tool for the analysis of financial markets is the market graph. This tool allows the analysis of several hundreds or thousands of relations between instruments. The market graph model is based on the early work of Mantegna (1999) who introduced graphs into the financial literature as a tool for dealing with size and number of relationships between/within economic agents. For example, graph modelling techniques have been previously applied in the banking sector by Boss et al. (2004) to analyze the spread of risk in an interbank system. It has been also used for describing the topology of the interbank payment system. Empirically or theoretically motivated questions can be answered by using graph-specific indicators and econometric methods. For instance, which markets tend to be clustered together?, What type of markets tend to be on the periphery? and why and when do the markets behave similarly?

This work introduces a novel analytical approach for the study of financialization. Such an approach is based on a market graph model which permits the study of relations between stock indexes. Thereby, the main contribution is the analysis of interactions between financial markets by considering both a market graph model and the transaction cost as a measure of integration. As far as the current literature concerns, the employment of transaction cost as a metric to build and analyze a market graph has not been previously addressed by the literature.

In the literature a common technique for dealing with interactions between financial instruments is the estimation of correlation indicators that are focused more on shape similarity between times series of prices. The performance of this type of approach heavily depends on the chronological consistency of the stock performance (e.g., return, volatility) to such an extent that an optimized portfolio could decrease performance for a time period due to an unclear consistency. In contrast, a graph approach provides some unique attributes for each node (stock) such as degree centrality, betweenness centrality and closeness centrality that represent the importance of each stock throughout the whole network. Unlike the correlation approach, these attributes are likely to be consistent over time by assuming that the network structure is consistent chronologically.

In this work, TCs are consider to be capable of explicitly representing the arbitrage between pairs of financial instruments so that the establishment of a relation based on TCs is possible. This relation permits the construction of a market graph which is a less abstract tool for the study of trading dynamics. The understanding of financialization through TCs dynamics opens a whole new research agenda since an approach based on TCs can contribute not only to debates related to arbitrage behaviour among countries, but also to the comprehension of social and economic phenomena within geographically separated financial markets.

The remainder of the article proceeds as follows: Sections 2 and 3 reviews literature related to TC and the market graph approach, respectively. Section 4 introduces the modelling approach. Section 5 describes the data sources and empirical analysis. Section 6 presents results. Finally, Section 7 summarizes the main conclusions.

2. Financialization and TCs in a geographical context

Stock markets are conceptualized as places consisting of issuers, investors and intermediaries that have locations and relate to each other in a physical space such as a region, city or country (Clark et al., 2007). Wójcik (2007) posits that money and finance are inherently a geographical phenomena. According to this author, the most recent financial crisis has geographical origins as well as geographical consequences. This is an indication that geography cannot be ignored in the analysis of financial networks.

The link between financialization and geographically separated markets has been scarcely addressed. In fact, financial geographers have pointed out that dominant debates on financialization are usually detached from geographical issues (Lee et al., 2009). As French et al. (2011) indicate, the literature on financialization has been inattentive to both the role of physical space in trading and the geographical aspects of money and finance. This is an important drawback of financial research since financialization is a deep spatial phenomenon. Sokol (2015) stresses that literature on financialization has so far spanned only three spatial scales (national economic space, firm/corporation and household/individual), whereas regional and international dimensions have been neglected. As a result, geography is regarded as either a mere empirical surface upon which processes of financialization are enacted and inscribed or an abstract spatial container of socio-economic relations. This author additionally argues that an extension of the subject beyond the geographical scale of money and finance is needed in order to scientifically address the interaction between geography and finance. Such a need can be tackled by taking advantage of modelling approaches based on networks. This study proposes a market graph model that supports the analysis of trading dynamics based on pure TCs.

From a descriptive view, TCs are classified as explicit and implicit (Boussema et al., 2001). Explicit costs include brokerage commissions, market fees, clearing and settlement costs, and any taxes. Financial transaction taxes are explicit because are defined and understood by all parties participating in a transaction. These parties settle these taxes before the occurrence of a transaction. Implicit costs are not included by trade prices. These costs depend mainly on trade characteristics relative to prevailing market conditions. The most important implicit cost is the bid–ask spread which is a compensation delivered to an entity or person that supplies liquidity in a transaction (Pollin et al., 2003).

Variations in TCs are produced by both the size and extent of trading in a market segment D'Hondt et al. (2008). Size is related to the amount of trade executed by each counterpart. Larger trades generate financial opportunities as a result of both economies of scale and the increase of financial spreads. This stimulates a fall of trading unitary costs. Trade extension is linked to trade volume. TCs are lower in markets with higher trading volume. The assumption is that more heavily-traded markets permit an easier timely trade. Between spatially separated regions, the market maker sets the prices by which traders can buy or sell. Traders can either buy or sell one unit of the asset or even to abstain from trading. If traders decide to trade, then TCs should be paid (Barrett and Bellemare, 2011).

In summary, the analysis of financial networks based on TCs dynamics opens the door to a new research agenda based on the relation between financialization and geographically separated markets. Moreover, this graph approach is consistent with the concept of financialization as an inherently spatial process between financial agents.

2.1. Evidence of TCs in international markets

The effects of TCs on international stock markets is an active research field. For example, Pollin et al. (2003) show that TCs in the American stock market are comparable to the U.K. market before adding the expense of the 50-basis point FTT (Financial Transaction Tax). Domowitz et al. (2001) demonstrated that TCs in the U.S. stock market are not consistently higher than other developed markets. The author reported that TCs are both roughly equal in the CDS (credit default swap) market and significantly higher in the market of mutual funds (at least as of 2012).

TCs directly affect the convergence of pricing returns since the degree transmission of price shocks provides clues about the reaction of a stock market (Cipriani and Guarino, 2006). Thereby, TCs can spread economic signals of a country to others countries (Fulop and Lescourret, 2009).

The seminal work of Thornton (2011) analyzes the relation between TCs and pricing return elasticity (Table 1). Several markets are considered such as stocks, foreign exchange, bonds and an ample range of derivatives (index funds, commodity futures markets and treasury futures markets). As a response to the establishment of TCs, the study concludes that elasticity

Table 1
Estimated elasticities of trading volume with respect to transaction costs, Thornton (2011).

Source	Country	Market	Elasticity	Measure
Baltagi et al. (2006)	China	Stock market	−1	TTC
	China	Stock market	−0.5	STT
Chou and Wang (2006)	Taiwan	Future market	−1	STT
	Taiwan	Future market	−0.6 to −0.8	BAS
Ericsson and Lindgren (1992)	Multinational	Stock market	−1.2 to −1.5	TTC
Hu (1998)	Multinational	Stock market	0	STT
Jackson and O'Donnell (1985)	U.K.	Stock market	−0.5(−1.7)[a]	TTC
Lindgren and Westlund (1990)	Sweden	Stock market	−0.9 to −1.4	TTC
	Multinational	Foreign exchange	−0.4	BAS
Wang et al. (1997)	United States	S&P 500 Index futures (CME)	−2.0	BAS
	United States	T-bond futures (CBT)	−1.2	BAS
	United States	DM futures (CME)	−2.7	BAS
	United States	Wheat futures (CBT)	−0.1	BAS
	United States	Soybean futures (CBT)	−0.2	BAS
	United States	Copper futures (Comex)	−2.3	BAS
	United States	Gold futures (Comex)	−2.6	BAS
Wang and Yau (2000)	United States	S&P 500 Index futures (CME)	−0.8(−1.23)[a]	BAS
	United States	DM futures (CME)	−1.3(−2.1)	BAS
	United States	Silver futures	−0.9(−1.6)	BAS
	United States	Gold futures	−1.3(−1.9)	BAS

TTC: total transaction costs; STT: security transaction tax; BAS: bid–ask spread.
[a] Long-run elasticities in parentheses.

varies if other financial instruments close to substitutes of taxed instruments are not subject to a transaction tax. For example, if a stock trading tax is active and no tax is affecting a stock option, then the market participants migrate from the stock market to a stock option market. This effect increases the elasticity of trading with respect to the transaction tax. If the stock option market is also taxed, the effect of a transaction tax becomes relatively weaker on both the stock and stock option market. Hence, a broadly designed transaction tax produces a smaller trading elasticity than a narrowly-targeted transaction tax assigned to a small number of market segments.

The measurement of TCs used for the determination of elasticities varies widely across studies. Some examples are total transaction costs, bid/ask spreads, and measures based on transaction taxes. The study introduced by Bismans and Damette (2012) analyzes different currency markets for U.S. dollars (Europe, the U.K., Japan and Canada) and reports data for nine different types of elasticity. The computed median elasticity is −0.36. Another work from the Institute of Development Studies (IDS) considers elasticity from the Chinese, U.K., and Swedish stock markets together with the broader U.S. securities market. The results of equity and securities markets show a median elasticity equals to −0.58. Since the trading elasticity is highly variable across specific regions, market segments and time periods, the results are severely affected by both the considered market segment and the potential market to be covered (Edwards et al., 2007). In this sense, the consideration of different financial instrument together with the use of a graph representation approach is a methodological innovation since pricing returns with TCs dynamics are merged in a spatially separated model.

3. The market graph

The search for patterns in financial markets requires the analysis of large data sets. A direct tool to represent the interactions within a data set is a graph. Nodes and edges are used for modelling relations between pairs of elements in the set so that the resulting graph possesses a structure that can be fully characterized by several topological measures such as clustering coefficients, degree distribution and density.

A seminal work addressing the use of graphs for the representation of financial interactions is Nagurney (2003), where the author introduces network models to explain the interactions that can occur in a financial system. Specifically, the study of the degree distribution in graphs has attracted attention in last years since the presence of power laws can be easily confirmed by computing the degree frequency. A power law is an evidence of the preferential attachment phenomenon which is the concept behind the notion of popularity (Rich-Get-Richer), see Barabási and Albert (1999).

Identifying the effect of a power law in financial stock markets is a problem addressed by few authors. The work of Boginski et al. (2003) can be regarded as an initial research in the subject. The authors introduce a special tool for the analysis of financial markets called “The Market Graph”. Basically, their approach builds a graph in which vertices represent a set of financial instruments. For any pair of vertices i and j, an edge is added to the graph if the corresponding correlation coefficient C_{ij} between price fluctuations is greater than or equal to a specified threshold θ. The resulting graph is known as the market graph which shows a power law in its degree distribution. Computational procedures to identify cliques and independent sets are also presented by the authors. In addition, cliques allow the identification of instruments whose price fluctuations behave similarly over time, whereas independent sets can reveal large completely diversified portfolios. Additional papers studying the structure of a financial market through the “The Market Graph” model are provided by Boginski et al. (2005, 2006).

Interactions in the banking sector have also been a financial system modelled by means of graphs. Attention has been mainly focused on the spread of risk in an interbank system. The network structure of the Austrian interbank market has been empirically studied by Boss et al. (2004). The existence of a liability between two banks (nodes) is the rule employed for drawing an edge. As a result, a power law distribution is featured by the featured graph. Soramäki et al. (2007) explore the topology of the interbank payments transferred between commercial banks. For doing this, the authors build a graph model based on transaction data from Fedwire©. Several topological measures are computed as well as analyzed. The conclusion indicates that the networks formed by payment flows share many features from complex networks, such as scale-free degree distribution (power law), high clustering coefficient and the small world phenomenon.

Similarly, Pröpper et al. (2008) present a manuscript where Dutch interbank payment flows are studied by computing several topological measures from an associated graph. The graph is constructed by using nodes as participants in the system and edges as transactions between participants. Hence, two nodes are connected if a transaction is generated between the corresponding participants. An interesting aspect of the article is the analysis of the vulnerability of the graph structure. Such analysis studies the resilience of the graph in the presence of either random or direct failures. Nier et al. (2008) model an interbank system through a network whose nodes are banks and each link represents a directional lending relationship. Links are generated by a probability of lending, which is assumed to be equal across all pairs of banks. The graph is populated with edges by a random process based on the lending probability. The authors also utilize the concept of “shock contagion” as a mechanism of operational as well as risk distribution. One main conclusion from the paper is more concentrated banking systems are prone to larger systematic risk. In the same lines, Gai and Kapadia (2010) conclude that the connection between nodes in this case are the claims issued between two banks.

Another work addressing transactions in a financial system is developed by Bech and Atalay (2010). The article investigates the topology of the federal fund market in the USA by employing a graph model. Nodes and edges are utilized for representing participants in the market and fund transfers, respectively. Finally, the manuscript presented by Martinez-Jaramillo et al. (2014) tackles the monitoring of systematic risk in the Mexican banking system. To do this, topological properties of the interbank exposures and payments system networks are analyzed. The main finding is that unlike the interbank exposures network, the payment system network is strongly connected.

Since financialization is a process by which economic, political, social, technological and suchlike concepts interrelate in a financial manner (Van der Zwan, 2014), the use of a graph approach conveniently suits for the study of such an interrelation dynamics. Furthermore, the use of a graph modelling approach permits the incorporation of geographical variables in the analysis.

The development of financial analysis based on spatial-geographic models provides better understanding of the globalization phenomenon which is crucial in the study of financialization.[1]

The understanding of transaction patterns between financial markets appears to be a key feature of the new financialized capitalism for which economic geography approaches has hitherto failed in fully characterizing both the explosion of financial networks and the causes of uneven development (Lazzarato, 2012; Lee et al., 2009). Despite a recent renewed interest among economic geographers in "geographical finances", a coherent geographically-informed approach of stock market integration and its spatialities does not seem to be found.

In conclusion, the concept of "financialization" and its study through graph models certainly provide understanding in regard to the relation between transaction patterns and geographically separated financial markets.

4. Model description

4.1. Estimation of transaction costs

In order to estimate TCs, this work applies a regime-dependent model known as The Threshold Vector Error Correction Model (TVECM), originally developed by Balke and Fomby (1997). More precisely, TVECM models are estimated for each cross combination of stock prices among each region.

The TVECM model presented by this work contains one threshold and two regimes according to the Akaike (AIC) specification criteria. This model is formulated as follows:

$$\Delta p_t = \begin{cases} \rho_1 \gamma' p_{t-1} + \theta_1 + \sum_{m=1}^{M} \Theta_{1m} \Delta p_{t-m} + \varepsilon_t, & \gamma' p_{t-1} \le \psi \quad \text{(Regime 1)} \\ \rho_2 \gamma' p_{t-1} + \theta_2 + \sum_{m=1}^{M} \Theta_{2m} \Delta p_{t-m} + \varepsilon_t, & \gamma' p_{t-1} > \psi \quad \text{(Regime 2)} \end{cases} \tag{1}$$

where $p_t = (p_{t,1}, p_{t,2})$ is the corresponding observation in period $t = \{1, \ldots, n\}$, of a two dimensional time series generated by a TVECM with two regimes. The time series are characterized by parameters ρ_k, θ_k and θ_{km} for $k = \{1, 2\}$ and $m = \{1, \ldots, M\}$. The threshold parameter ψ permits an asymmetric price adjustment for the long run equilibrium. ψ is also interpreted as the TCs between a pair of markets (Ihle et al., 2008). As Baulch (1997) states, this parameter represents the band within which trade is not profitable in either markets or sectors.

4.2. Graph model based on transaction cost

A graph is utilized by this work for representing the interactions between pairs of financial instruments. A graph $\mathbf{G} = (V, E)$ is a structure consisting of a finite set V of elements called vertices and a set E of unordered pairs of vertices called edges. For this study, the set V is conformed by financial instruments whereas the set E is composed by undirected edges linking pairs of instruments satisfying a particular condition. Undirected edges refer to edges provided with no specific direction from one vertex to another. The construction of the graph $\mathbf{G} = (V, E)$ considers two times series i, j to be connected by an undirected edge if the corresponding transaction cost ψ is less than a specified threshold δ. Thereby, different values of δ generate several undirected graphs $\mathbf{G} = (V, E)$ with a same vertex set V but an edge set E differing from one graph to another.

A graph for a specific δ is guaranteed to be both free of loops and with only one edge between any two nodes. Moreover, if the graph cannot be strongly connected, the presence of some isolated nodes and some connected components (subgraphs) is possible. An isolated node has no link to any other nodes, and a connected component may be a complete graph.

In view of the authors, a market graph model based on transaction cost is a complete tool for the study of financilalization dynamics. Several structural measures allow the analysis of such dynamics. Although, the use of graphs approaches in the study of finances can be previously found, the use of a transaction cost threshold as an edge-creation condition is an innovative feature of the model.

[1] Dore (2008) describes financialization as "it is a bit like globalization".

4.3. Structural measures of the graph model

Several topological measures can characterize the structure of a graph. The measures and properties used in this work are described below.

4.3.1. Vertex degree and degree distribution

The degree of a vertex is defined as the number of edges incident to the vertex (Diestel, 2005). Highly connected vertices can be identified by the calculation of each vertex degree. In the light of graphs based on TCs, high degree vertices are financial instruments whose transaction cost satisfied the threshold condition with many others. Special attention has to be given to those vertices with the highest degree. Such vertices tends to define the dynamic of the market since a change in these instruments is able to affect a significant portion of the entire market.

Determining the number of vertices with a given degree allows the establishment of a degree distribution. The importance of the degree distribution is related to the preferential attachment phenomenon that is behind of the notion of popularity. The presence of preferential attachment is corroborated by showing if the corresponding degree distribution fits a power law. A complete description of the phenomenon is given by Easley and Kleinberg (2010).

In the context of the market graph, vertex degrees shed some light on “contagion” patterns. The transmission of disruptions across markets mainly depends on three factors (Vath, 2007). First, the presence of an insider, that is, individuals who trade non-public information about company stocks and/or securities. Second, through a market manipulation strategy, where prices are assumed to depend directly on the trading strategies. Third, through the liquidity risk in terms of the differences between the bid and ask prices, i.e. the existence of a bid–ask spread. In the case of high degree vertices, the last option appears to be the most relevant in the formation of the linking process among vertices (Onnela et al., 2003). Transaction costs are one way to model the bid–ask spread and the transmission of disturbances across markets could influence arbitrage activities among traders, thus affecting the liquidity risk, see Lee et al. (2001).

4.3.2. Size of the maximal clique

A clique is a complete subgraph $\mathbf{G}' = (V', E')$ of $\mathbf{G} = (V, E)$ such that $V' \subseteq V$, $E' \subseteq E$. A complete subgraph is a graph where each subgraph vertex has an edge with all other vertices in the subgraph (Lawler, 1976). The largest complete subgraph of **G** is called *maximal clique*. The size of a clique is defined by the number of vertices that it contains. For this work, the relevance of cliques lies on the possibility of clustering financial instruments based on a similarity criterion (Boginski et al., 2006). This similarity criterion is provided by the transaction cost in the case of the graph based on TCs. As a result, financial instruments in a clique conform a cluster of instruments sharing a similar transaction cost criterion (threshold δ).

5. Data description

A total of 96 sectorial price indicators across 23 stock markets are considered. All interactions are 28.224 which corresponds to 168 different instruments. These instruments belong to markets within countries attached to four notable trading blocs: EU (European Union), MERCOSUR (Southern Common Market), NAFTA (North American Free Trade Agreement) and APEC (Asia Pacific Economic Cooperation).

The timeframe of this study ranges from July 2012 to July 2014. All the stock market indexes were collected from Morgan Stanley Capital International (MSCI). To estimate the global portfolio index, the MSCI All Country World Index is used as a proxy. The U.S Treasury bill rate obtained from the U.S. Department of the Treasury is also used as a proxy for the world risk-free rate. The rest of the variables were taken from the International Monetary Fund (IMF), the COMTRADE Database from the United Nations (UN) and the World Bank (WB).

All TC data are subsequently organized in a matrix where each cell corresponds to the TC between two instruments. Next, a filter is applied over the matrix so that only those cell meeting the threshold condition remains. Next, the resulting matrix is employed as an adjacency matrix to generate an indirected graph. As an illustration, Fig. 1 shows a resulting graph for a threshold $\delta = 0.05$.

6. Results and discussion

6.1. Degree distribution

The power law is a ubiquitous phenomenon that can be identified in graph models by analyzing the degree distribution. Note that this study considers a set of graphs generated by different threshold values δ. Therefore, the degree distribution results are different for each particular δ (see Fig. 2). It is noticeable that as δ increases the financial instruments tend to establish more direct connections with others (degree). On the contrary, small values of δ reduce the number of vertices having a large degree. The results suggest that the degree exponent is smaller in networks with high δ. Therefore, the connectivity of a vertex with a large degree becomes higher. This behaviour intuitively indicates the presence of preferential attachment within this group of financial instruments. This insight suggests that the effect of the degree exponent is smaller in networks with high δ. In other words, the number of connected vertices decreases as the threshold increases.

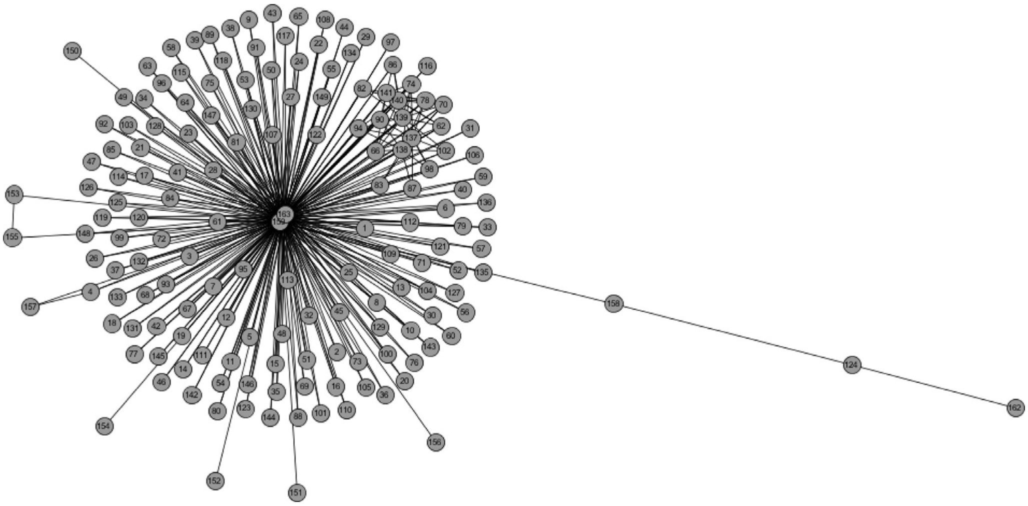

Fig. 1. Resulting graph for a threshold $\delta = 0.05$.

Mantegna (1999) suggests that a fixed threshold value increases the mean degree during a financial crisis, which indicates more interaction among indexes in this period. Therefore, the connectivity of a vertex with a large degree becomes higher so that the network tends to be more centralized around a few vertices. Results also indicate the presence of preferential attachment, further suggesting that several powerful companies make a dominant effect on the whole market. As a result, an important level of concentration among some indexes is noticeable.

Current literature focuses on how market concentration affects the adoption of risk by firms, a concept with direct correspondence to the probability of firms distress. For example, Cetorelli and Goldberg (2012) suggest a negative link between market concentration and the probability of firm distress. The findings on degree distribution are important to policymakers as well as other market participants that focus on potential threats in market stability. From an empirical perspective, the findings have different implications. Hellmann et al. (2000) argue that banks in concentrated markets have incentives to reduce risk. Hence, if higher concentration implies a decrease in competition and an increase of profits, then banks franchise are higher.

The increase of the concentration level is linked to higher threshold values and, therefore, markets frictions. Following Stiroh (2006), most of the financial instruments traded in markets with high levels of TCs are prone to higher risk levels which could affect pricing returns. In this sense, Carlin et al. (2004) discuss that a market with a few large players will be stable most of the time, as firms optimally choose to act as cooperating oligopolists and establish long term capitalization strategies to absorb possible market frictions.

Results on vertex degree formation suggest that lower threshold values represent higher levels of market efficiency as a result of a more homogenous distribution. This suggestion is based on Fama (1998) who states that for a pair of markets trading with each other, a competitive market equilibrium only exists if inter-market price differs only by the value of the transaction costs incurred by either capital flows or price signals.

The connectivity of arbitrage processes between markets defines the level of market integration. Barrett and Li (2002) indicate that developing markets are expected to have either more segmented or uncorrelated inter market prices. This occurs whenever the differential of inter-market price equals (is less than) the transactions costs. In this work, one important implication of the vertex degree structure is the fact that any financial policy acting over some markets in the system may not necessarily affect to those markets outside the direct impact of the policy. Furthermore, market unbalances in the system may not be restored since the "shockwaves" are not transmitted throughout the system but rather absorbed by the market receiving the waves.

6.2. High degree vertices

For a decision maker it is important to focus on those instruments (vertices) defining the conduct of the entire market. Vertices with high degree are particularly critical since any disturbance is rapidly spread throughout the market as a result of the high number of direct links to other vertices.

Table 2 shows the highest degrees values for several δ thresholds.

In a general context, the vertices that concentrate most of the disturbances transmission are associated with the affiliation of trading blocs. APEC countries such as Japan, Australia and USA transmit their disturbances faster than European and CER countries. It is possible to infer that despite achieving the highest level of economic integration, i.e. monetary union, EU bloc is less integrated. This situation implies that the EU might not be as integrated as it is thought. One possible explanation is the number of markets involved: the higher the number of markets, the harder the convergence process.

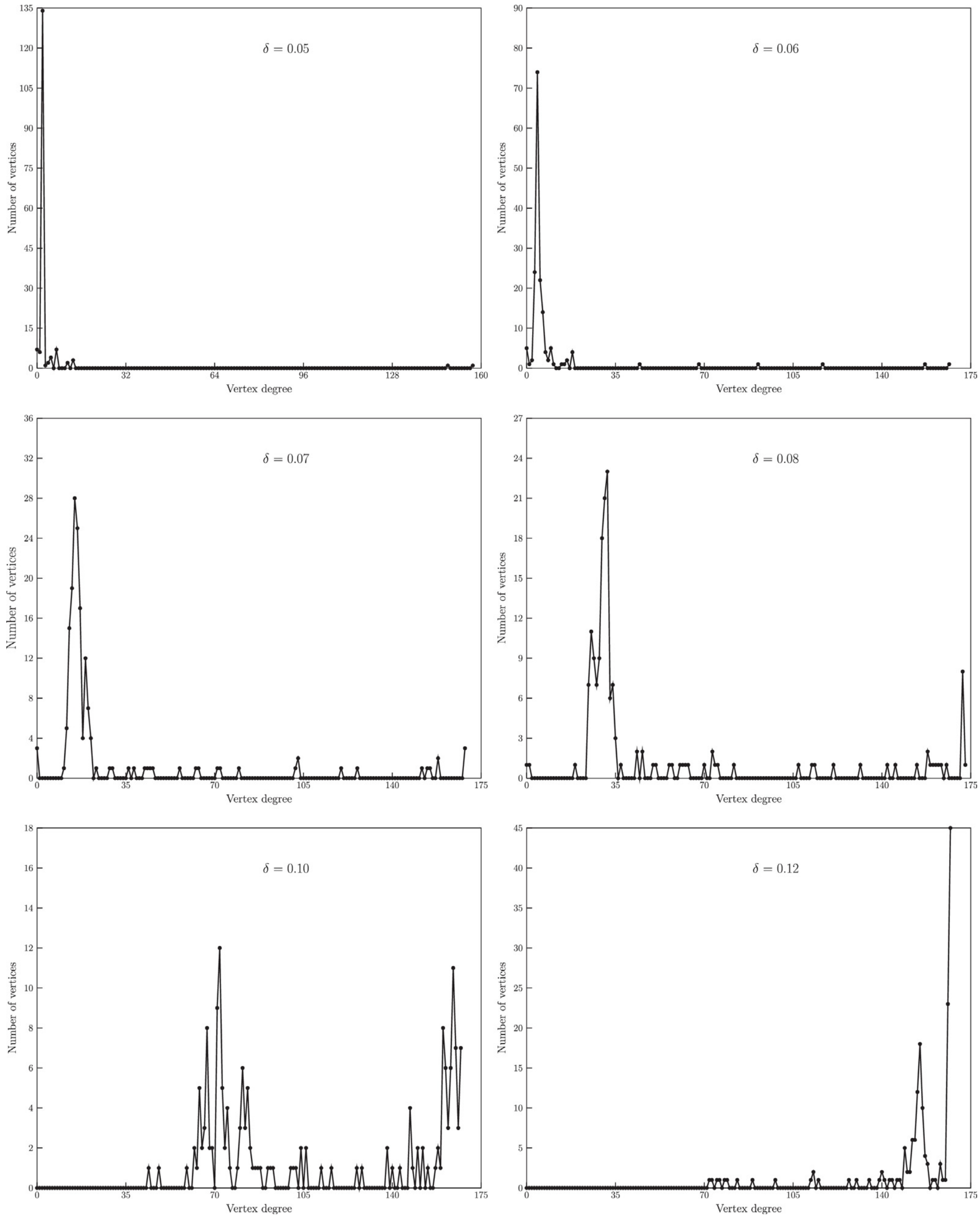

Fig. 2. Degree distribution for different threshold values.

Firms that depends mainly on international pricing to define stock returns (such as volatility and commodity indexes) develop strong connections. In the case of volatility, this situation could be a result of the recent episodes of market instability (e.g. the U.S. credit crisis, commodity price rallies or macroeconomic instability on developing countries). According to Syriopoulos (2011), volatility constitutes an inbuilt mechanism of short-term destabilization and uncertainty of country economic performance. Similarly, Jaillet and Lu (2013) demonstrated that recent commodity swigs creates new patterns in trade strategies as a result of increasing volatility risk.

According to Reitz and Westerhoff (2007), the transmissions of disturbances is a reflection of the actual and expected shift of demand-supply due to the anticipated demand of commodities. Results in high vertex degrees are consistent with results found in Dillon and Barrett (2013). The authors show that high price correlations between energy prices and other commodities promote the transmission of shocks among commodity-oriented countries due to factors such as climate change, crop substitutions, higher transportation costs and input costs in production and marketing. From an arbitrage

Table 2
Highest degree vertices.

Threshold δ	Highest degree values	Markets with highest degree (MSCI codes)
0.05	157	usasust7
	148	asiavol7
	13	jpinfr6,usainfr6,asisvol6
0.06	157	usasust7
	148	asiavol7
	110	ausinfr6
0.07	159	usasust7,uksust7,japsust7
	149	asiavol7,usainfr7
	146	ausinfr6
0.08	163	asiavol7
	162	usacomm7,acwiemr7,auscomm7,japsust7 uksust7,usasust7,ausinfr7,jpinfr7
	156	cansust7
0.10	167	kukjevol7,acwivol7,asiapcomm7 asiaexjpAFC7,asiapacAFC7,asiaAFCH7 fareastvol7
	166	acwivol7,japsust6,cansust6
0.11	167	ausinfr7,jpinfr7,usainfr7,asiavol7,asiapacvol7 eurvol7,fareastvol7,acwivol7,kukjevol7,acwicomm7 auscomm7,jpcomm7,usacomm7,acwiemr7,aussust7 cansust7,japsust7,uksust7,usasust7,fareastvol7 acwivol7,kukjevol7,asiaAFCH7,asiapacAFC7,asiaexjpAFC7 acwiAFC7,asiapcomm7,jpcomm6,usacomm6,acwiemr6,aussust6 cansust6,japsust6,uksust6,usasust6,ausinfr6,asiaAFCH6 asiapacAFC6,asiaexjpAFC6,acwiAFC6,asiapcomm6,acwicomm6

Table 3
Maximal cliques.

Threshold δ	Maximal clique size	Number of maximal cliques	Sample cliques (MSCI codes)
0.05	3	104	[jpinfr6,uksust3,usasust7] [auscomm5,usainfr6,uksust3]
0.06	5	27	[ausinfr6,usacomm7,acwiemr5,aussust7,usasust7] [auscomm7,ausinfr6,usacomm7,usainfr4,usasust7]
0.07	13	2	[jpcomm6, acwiemr6, cansust6, uksust6, ausinfr6, asiapcomm7, acwicomm7, auscomm7, usacomm7, aussust7, japsust7, uksust7, usasust7]
0.08	22	4	[jpcomm6, ausinfr7, jpinfr7, acwiemr6, asiavol7, cansust6, japsust6, uksust6, ausinfr6, asiapacAFC7, asiapcomm7, acwicomm7, auscomm7, jpcomm7, usacomm7, acwiemr7, aussust7, cansust7, asiapcomm6, japsust7, uksust7, usasust7]
0.10	68	2	[jpcomm6, usacomm6, acwiemr6, aussust6, cansust6, japsust6, uksust6, auscomm, usasust6,jpcomm, ausinfr6, usainfr6, asiapacvol6, japsust, fareastvol7, acwivol7, asiaAFCH7, asiapacAFC7, asiaexjpAFC7, asiapcomm7, acwicomm7, auscomm7, jpcomm7, usacomm7, acwiemr7, aussust7, cansust7, asiapcomm2, japsust7, acwicomm2, uksust7, auscomm2, usasust7, jpcomm2, ausinfr7, jpinfr7, asiavol7, japsust2, acwivol7, kukjevol7, jpinfr2, asiapcomm4, acwicomm4, auscomm4, jpcomm4, japsust4, jpinfr4, asiaAFCH5, asiapacAFC5, asiaexjpAFC5, acwiAFC5, asiapcomm5, acwicomm5, auscomm5, usacomm5, acwiemr5, aussust5, japsust5, uksust5, usasust5, jpinfr5, usainfr5, asiavol5, eurvol5, fareastvol5, acwivol5, asiapacAFC6, acwicomm6]
0.11	108	4	too large to fit in this table

perspective, Andrews (2014) suggests that this contagion effect stems from the massive liquidation of long positions in commodity futures markets and other over-the-counter (OTC) deals from portfolio investors.

The impacts of these disturbances on trade decisions are twofold. In resource poor countries food and fuel crises promote rapid depreciation of national currencies against the U.S. dollar and affect the balance of payments and fiscal deficits. On the other hand, among resource-rich countries, middle-income countries with stabilization funds could ride through the short-term price cycles; but many fragile LICs, external shocks of this magnitude increase their fragility.

Overall, the unprecedented magnitude of swings in commodity prices in the medium term as well as excessive volatility are likely to be an outcome of both a higher number of links between activities in commodity markets and finances associated to increasing volatility risk.

6.3. Maximal cliques

Maximal cliques are interpreted as groups of markets sharing an equal threshold value. This idea helps to define cliques as clusters in a market graph with high number of edges. Attention is paid to the number of cliques presented in a market graph, since it is an indicator of the concentration structure of a graph. In addition, those cliques with the largest number of vertices provide a hint about a group of instruments driving the behaviour of the entire market. For this case, infrastructure, sustainability and commodity price indexes concentrate the maximal cliques within the sample (Table 3). Threshold values are adopted as a similarity measure for the trading behaviour of two investors. Therefore, a proper δ is of substantial importance to guarantee performance. The results evidences no presence of a diversified investment portfolio in which the price fluctuation correlation coefficient is negative. Hence, the price of stocks do not demonstrate enough variation. In other words, the connectivity of a stock network becomes more sensitive to a selective removal when threshold values increase. This produces sparser networks and non-uniform degree distribution for higher thresholds. At this time, the vertices that have a large degree are always "key" members of a large component. These members could represent large firms that concentrate markets and influence the price fluctuation correlation of the network.

7. Conclusions

Fiancialization provides a theoretical framework for understanding the complex interactions within financial networks. This study investigates the dynamics of financial markets by considering such a framework as a main guideline. In addition, a market graph built from TC-data is selected as a modelling tool for the study of interaction between geographically separated stock markets.

Compared to previous works, the obtained market graph based on TCs shows a consistent set of outcomes that explain current trading dynamics. The degree distribution evidences that the market graph tends to establish more direct connections between instruments when transactions costs increases. These results suggest the presence of preferential attachment. Therefore, a strong transmission of price signals towards the rest of the markets is appreciated from several important companies.

The findings also showed that transmission of disturbances are apparently linked to specific trading blocs. This confirms that the characteristics of the markets as well as the development of each country affect the intensity by which price shocks are spread. Due to connection intensity is related to market cohesion, the level of integration of the APEC countries such as Japan, Australia and USA is higher than European countries. Likewise, integration in CER markets are higher than in the EU. At an individual level, the commodity and volatility price indexes concentrate the highest degree vertices among the variables.

Finally, an inverse relation between the threshold value (TC) and maximal clique size is observed. The size of the maximal clique defines groups of instruments that mostly drives the behaviour of the entire market. Within the current framework, infrastructure, sustainability and commodity indexes from APEC, EU and NAFTA dominate the conduct of the markets.

In summary, a market graph model based on transaction cost is a complete tool for the study of financialization dynamics. Although, the use of graphs approaches in the study of finances can be previously found, the methodology and results presented are a contribution due to both the use of transaction costs as a graph building condition and the contextualization of the work within the financialization literature.

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