NETWORK CORPORATE GOVERNANCE: INFORMATION AND RISK-RETURN SHARING OF CONNECTED STAKEHOLDERS

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Abstract

Traditional corporate governance patterns are based on the interaction among composite stakeholders and the various forms of separation between ownership and control. Shareholders, debtholders, managers, employees, suppliers, and clients cooperate around the Coasian firm represented by a nexus of increasingly complex contracts. These well-known occurrences have been deeply investigated by growing literature and nurtured by composite empirical evidence. Apparently unrelated network theory is concerned with the study of graphs as a representation of (a)symmetric relations between discrete objects (nodes connected by links). Network theory is highly interdisciplinary, and its versatile nature is fully consistent with the complex interactions of (networked) stakeholders, even in terms of game theoretic patterns. The connection between traditional corporate governance issues and network theory properties is however still under-investigated. Hence, the importance of an innovative reinterpretation that brings to "network governance". Innovation may for instance, concern the principal-agent networked relationships and their conflicts of interest or the risk contagion and value drivers – three core governance issues. To the extent that network properties can be mathematically measured, governance issues may be quantified and traced with recursive patterns of expected occurrences.

1. INTRODUCTION

Corporate governance issues and the interactions among composite stakeholders may well be represented and interpreted in graphical terms, connecting stakeholding nodes (vertices) with their interactions (links or edges).

Even though both corporate governance and network science are well-grounded theories, their possible connections have been hardly investigated and, to the author's knowledge, there are no specific studies about their joint analysis. The research is so original and may ignite a new literature strand.

Consistently with this framework, the research question of this study is concerned with the possibility to represent the interactions among stakeholders – a core corporate governance concern – through network patterns and properties.

The expression "network governance" has already been used by Jones et al., 1997, referring to some interaction between transaction cost economics and social network theories. The perimeter of this study is, however, wider.

To the extent that networks can be expressed in mathematical terms, through adjacency or incidence matrices, interactions among stakeholders may be measured, especially if they follow recursive patterns.

The main corporate governance issues that can be interpreted using network theory may, for instance, concern:

1. Diffused versus concentrated ownership structure, and the consequent links between many or few "nodes" of shareholders with the firm and the other stakeholders;
2. Large versus fragmented creditors;
3. The link between the (listed) firm, its stock market, and the worldwide markets, each representing a node correlated to the others;
4. A reinterpretation of the theory of the firm as a Coasian nexus (network) of contracts;
5. The spread of information among networked stakeholders;
6. Value creation with digital scalability, where intangible nodes grow exponentially, increasing the value of the network;
7. Value destruction due to (strategic) node deletion;
8. Interfirm coordination;
9. Interlocking directorship among board members of different firms;
10. The impact of network analysis and game theory on interactive agents.

The study is organized as follows: after an introductory section about network theory, the main governance points will be synthetically analyzed, with emphasis on the open issues that are closer to a "networked" interpretation.

A discussion with indications for future research and some critical considerations will precede the concluding remarks.

2. NETWORK THEORY

Network theory is the study of graphs as a representation of either symmetric relations or asymmetric relations between discrete objects. In computer science and network science, network theory is a part of a graph theory: a network can be defined as a graph in which nodes and/or edges have attributes (e.g. names).

An interdependent network is a system of coupled networks where nodes of one or more networks depend on nodes in other networks. Such dependencies are enhanced by developments in modern technology. Dependencies may lead to cascading failures between the networks and a relatively small failure can lead to a catastrophic breakdown of the system. Blackouts are a demonstration of the important role played by the dependencies between networks.

Networks represent a fundamental characteristic of complex systems whose connected structure may give an innovative interpretation of the interactions among (linked) stakeholders.

Network theory has applications in many disciplines including statistical physics, particle physics, computer science, electrical engineering, biology, economics, finance, operations research, climatology, ecology, and sociology. Applications of network theory include logistical networks, the World Wide Web, Internet, gene regulatory networks, epidemiology, metabolic networks, social networks, epistemological networks, etc.

The links of a network can be directed or undirected. Some systems have directed links, like the www, whose uniform resource locators (URL) point from one web document to the other, or phone calls, where one person calls the other. Other systems have undirected links, like transmission lines on the power grid, on which the electric current can flow in both directions. A network is called directed (or digraph) if all its links are asymmetric, and cause-effect relationships are only one-way; it is called undirected if all its links are symmetric (one-to-one). Some networks simultaneously have directed and undirected links.

Most relationships in corporate governance are bi-directional and so undirected.

A key property of each node is its degree, representing the number of links it has to other nodes. The degree is an important parameter even in corporate governance, as it identifies the connections among stakeholders and their intensity.

Edges among nodes (i.e., stakeholders) represent (Estrada and Knight, 2015):
  – Physical links (pairs of nodes can be physically connected by a tangible link);
  – Physical interactions (connection determined by a physical force);
  – Ethereal (intangible) connections (information or other immaterial links);
  – Geographic closeness between nodes;

–   Social connections (friendship, collaboration, family ties, etc.);
–   Functional linking (actions that activate other activities).

Nodes may not be directly linked by an edge but still have some bridging relationships, through a walk (trail) among distinct edges.

The study of degree distribution is particularly suited to the analysis of complex networks (Estrada & Knight, 2015, p. 95).

Scale-free networks are consistent with corporate governance patterns and with the presence of hubs represented by pivoting stakeholders (large creditors; managers; key shareholders, etc.). Once the hubs are present, they fundamentally change the system's behavior.

Networks can be interpreted in both static and dynamic terms that represent their evolution and may be used also for predictive purposes. Evolving networks can predict the growth rate of a node that may depend on its age, and contribute to the interpretation of dynamic governance issues.

Another important concept is represented by internal links. In many networks new links not only arrive with new nodes but are added between pre-existing nodes. For example, the vast majority of new links on the www are internal links, corresponding to newly added URLs between pre-existing web documents. Similarly, virtually all new social/friendship links form between individuals that already have other friends and acquaintances.

Internal links represent an important feature of the firm that has a strong bulk of inside stakeholders that are closely tied among them, with further links to other external stakeholders.

Figure 1 shows how internal and external stakeholders interact around the company that represents the pivoting hub.

Figure 1. External vs. internal stakeholders
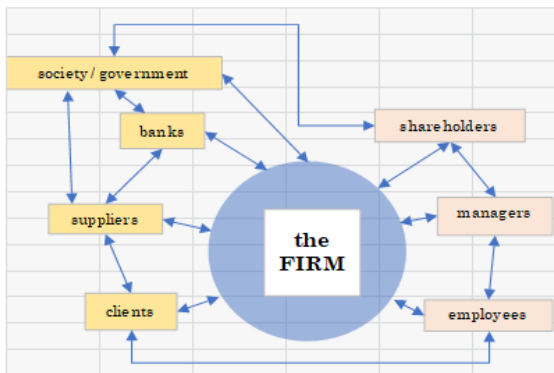
2.1. Social networks

Social network analysis examines the structure of organizational networks and relationships between social entities that can be represented by interacting stakeholders.

(Social) networks are often used to interpret the behavior of communities. The employees of a company are more likely to interact with their coworkers than with employees of other companies. Consequently, workplaces appear as densely interconnected communities within the social network. Communities can be detected with hierarchical clustering that is based on a similarity matrix that measures the distance between two nodes. Communities can be dense or sparse, are typically overlapping and they have communicating and clustering links. Communities in social networks tend to be nucleated around strong ties that may be represented by hubs. These properties have evident governance implications.

Assortativity or assortative mixing is a preference for a network's nodes to attach to others that are similar. Though the specific measure of similarity may vary, network theorists often examine assortativity in terms of a node's degree. The addition of this characteristic to network models approximates the behaviors of many real-world networks. Assortative mating reflects the tendency of individuals to date or marry individuals that are similar to them. In assortative networks, hubs tend to connect to other hubs and small-degree nodes to similar nodes. In a network environment, we can also encounter the traditional assortativity, when nodes of similar properties link to each other.

Correlations between nodes of similar degree are often found in the mixing patterns of many observable networks. For instance, in social networks, nodes tend to be connected with other nodes with similar degree values. This tendency is referred to as assortative mixing, or assortativity. On the other hand, technological and biological networks typically show disassortative mixing, or disassortativity, as high degree nodes tend to attach to low degree nodes (Newman, 2002).

In assortative networks, nodes of comparable degree tend to link to each other: small-degree nodes to small-degree nodes and hubs to hubs. In neutral networks, nodes link to each other randomly. In disassortative networks, hubs tend to connect to small-degree nodes and small-degree nodes to hubs.

Social networks are assortative, and stakeholders typically behave accordingly.

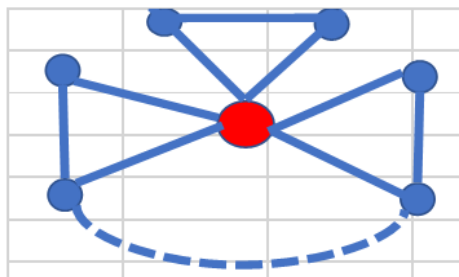**Figure 2.** Interaction among users of a social network
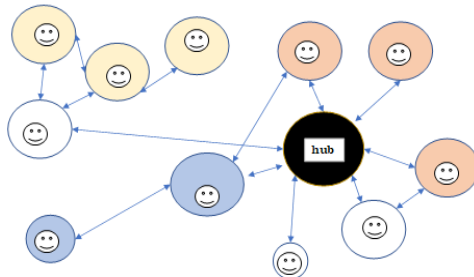
2.2. Clustering networks

Many real-world networks are characterized by the presence of a relatively large number of triangles.

A network formed by triangles joined at a central node (Estrada & Knight, 2015, p. 103) can be represented in Figure 3.

Figure 3. Clustering triangular networks

This representation is consistent with a firm (hub at the center) and its stakeholders that can be grouped in converging triangles, each representing a category (shareholders, managers, employees, etc.). Adjacent triangles may well be linked among them.

3. DIFFUSED OR CONCENTRATED OWNERSHIP STRUCTURE? PUBLIC COMPANIES VERSUS FAMILY BUSINESSES

The ownership structure considers two corner solutions where shareholders are either diffused (mainly in listed public companies) or concentrated in family businesses. The number of the shareholders (each representing a node) and the links among them and with other stakeholders is fully consistent with network theory.

Diffused ownership is typical of large corporations that are listed and are characterized by a high degree of separation between ownership and control: atomized shareholders act like principals that delegate the management of the firm to professional agents.

In family businesses, principals and agents tend to overlap and, in many cases, coincide. Internal ties are stronger within the family firm, whose dimensions are typically smaller than that of public companies. The obsession to keep control under the family often limits growth opportunities.

Diffused ownership in public companies can be interpreted in terms of networking links among stakeholders (nodes), without (Figure 4 or with Figure 5) the intermediation of institutional investors that often act as proxy-collectors, concentrating the voting power and acting as a hub linked to otherwise uncorrelated nodes.

**Figure 4.** Networking stakeholders in a public company
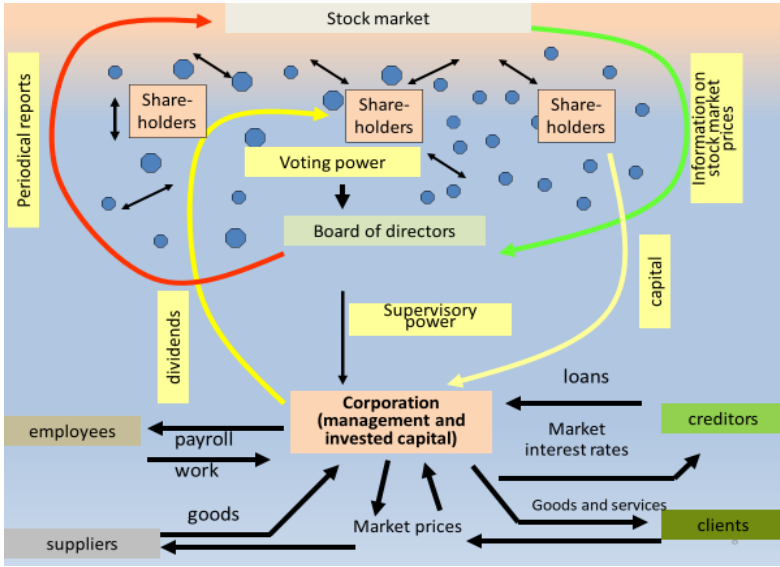
**Figure 5.** Institutional investors (proxyholders) in a public company
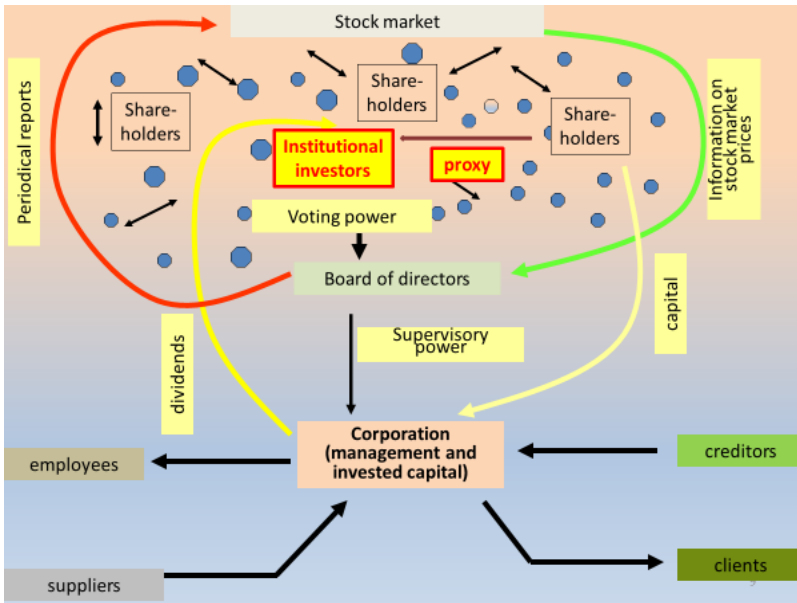
Family businesses or even public companies may be part of a group that can be pyramidal or take the shape of a "comb" and develop horizontally. In the former case, there is stock leverage, according to which the ultimate shareholders of the holding company minimize the equity-holding necessary to control the operating companies. This brings to well-known opportunistic behaviors.

Both structures can evidently be conceived in terms of networks, where each firm is the node and shareholdings represent the edge.

Figure 6. Pyramidal group
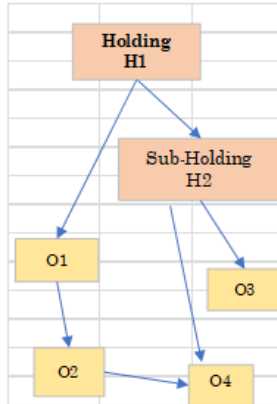
Figure 7. Horizontal group
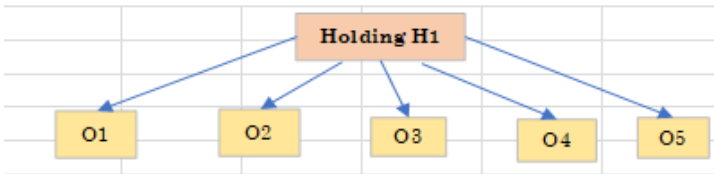
Shareholdership is fragmented in family businesses that get articulated along generations, for inheritance reasons. Common control can be kept through unifying holding companies that are positioned at the vertex (hub node) of the group. If the tree ramification of the family grows above the holding company, then control over the operative firms is preserved. Trees are graphs lacking cycles and they are rooted if they have a single vertex (van Steen, 2010; Chapter 5), for instance, represented by the holding company.

Figure 8. Ascendant generational ramification (preserving the "hub" holding company)
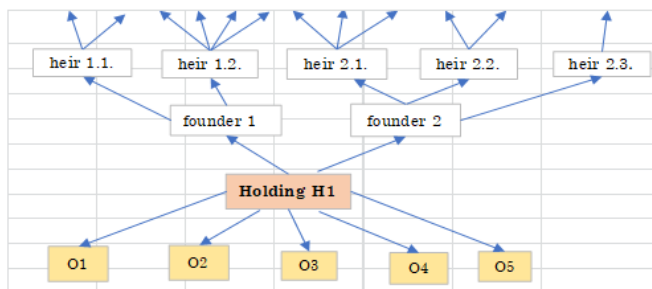
Group companies may be represented by articulated networks in the case of the interlocking Japanese keiretsu or the Korean chaebol (Han, 2016), synthetically recalled in Section 8.

## 4. CORPORATE GOVERNANCE AND THE FINANCIAL MARKETS

When a firm is listed, its ownership is diffused (see paragraph 3.) and the market value of its shares reflects the stock market price. The market price of the firm is sensitive to the domestic stock market that hosts the firm and the sensitivity parameter is expressed by the beta (ß) of the listed stock against the volatility of the market.

But stock markets are also linked among them and so the intrinsic volatility of each market is transmitted to other markets through their correlation: the higher the correlation, the bigger the risk sharing through contagion.

The interactions between the listed firm and the other firms of the same (domestic) market contribute to the overall market volatility. Interconnectivity among stock markets brings to overall volatility (systemic risk) that cannot be further reduced through international diversification.

These well-known properties can be interpreted in network terms that represent the macro-links between the stock exchanges and the micro-links within domestic stock markets. Spreading phenomena and epidemic modeling of contact networks can explain the propagation of risk among different stock markets.

**Figure 9.** International portfolio diversification
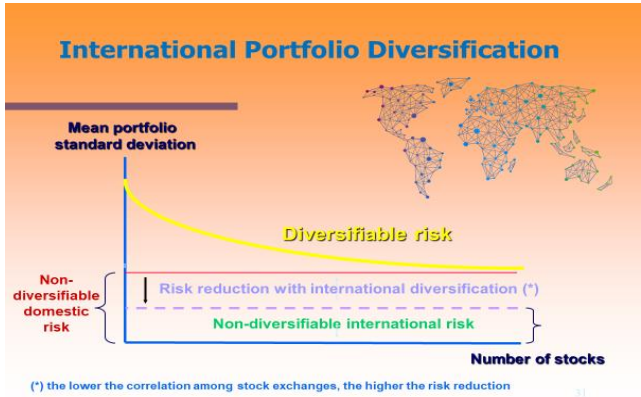
5. THE FIRM AS A COASIAN NEXUS (NETWORK) OF CONTRACTS

The firm can be considered as a nexus of contracts both internally, so justifying in a Coasian way its very existence, and externally, should agreements with third parties be considered, within a broader framework.

This interpretation is fully consistent with the network theory since nexuses are the links among different nodes (here represented by composite stakeholders, in a multilayer framework).

Consider an initial situation where there is no firm. Each node represented by a blue circle can have different links with the others. Figure 10 shows an increasingly linked framework where the network (a) is initially empty (since there are no links among the different nodes) and then becomes increasingly linked with more and more edges (b → c →d).

Figure 10. Network (without a firm)
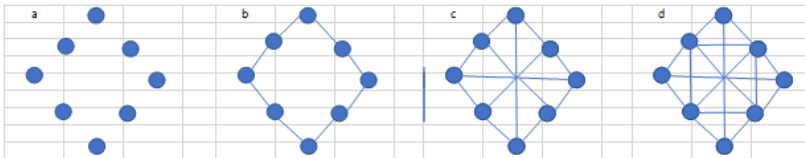
A different situation occurs when at the center of the "crossroad" among the different nodes there is a hub represented by the firm.

Nodes are increasing. In the situation represented by (e) in Figure 11, the hub is the only pivoting entity: each stakeholder must pass through the hub to communicate with another node; in situation (f) or (g) nodes are also (increasingly) linked among them, without necessarily passing through the hub.

Figure 11. Network with a hub firm
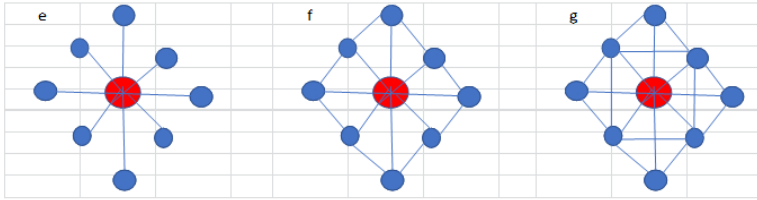
From Figures 10 and 11, it intuitively appears that the hub/firm adds value to the whole network. This may be considered a "graph-theory" interpretation of the theory of the firm.

Nexuses of contracts are also consistent with supply and value chains where stakeholders interact to co-create shared value. Supply chains will be examined in Section 12.

External nexuses of contracts typically involve synergic stakeholders, linked to the firm with pass-through contracts or other cooperation agreements; while stakeholders always include shareholders, they typically go beyond this core character, being also represented by debtholders, clients, suppliers, workers, and public authorities, up to the civil society surrounding the company and interested in its well-being.

Vertical integration represents a well-known form of networked cooperation, within the "make it or buy" strategic decision that stands out as one of the basic elements of the theory of the firm, as illustrated by Williamson (1985), Holmstrom and Tirole (1989), and Hart (1995, part I). In microeconomics, vertical integration describes a management control system where companies within a vertical supply chain are controlled by a common owner. The specialization of each firm within the vertical value chain allows a synergic combination of products and services, cementing upstream buyers with downstream suppliers.

The value chain is consistent with the networking stakeholders that rotate around it.

The Coasian rationale behind the ontological existence of the firm, considered as a nexus of contracts, may tentatively be extended to a wider framework, where the firm is analyzed within its broader legal "web"; the internal nexus of contracts may so be expanded to consider also external legal agreements. The firm is the "glue" that brings together many heterogeneous stakeholders.

The Coasian theory of the firm is linked to transaction economics. Ketokivi and Mahoney (2017) make some key questions about the issue: "Which components should a manufacturing firm make in-house, which should it co-produce, and which should it outsource? Who should sit on the firm's board of directors? What is the right balance between debt and equity financing? These questions may appear different on the surface, but they are all variations on the same theme: how should a complex contractual relationship be governed to avoid waste and to create transaction value? Transaction Cost Economics is one of the most established theories to address this fundamental question".

The concept of node centrality (Estrada & Knight, 2015, Chapter 14) is used in the determination of the most important nodes in a network, acting as hubs. Their characteristics include the ability to communicate directly with other nodes, their closeness to other nodes, and their role to act as a communicator between different parts of a network. Usefulness – up to indispensability – of central nodes is fully consistent with the Coasian nature of the firm as a nexus (network) of contracts and ties among composite stakeholders.

Degree centrality measures the ability of a node to communicate directly with others, this being a founding characteristic of the firm. Firms also have a closeness centrality, having the shortest path distance with other nodes represented by surrounding stakeholders. Furthermore, firms are characterized by their betweenness centrality, being a key communication node between other pairs of nodes. Closeness to other nodes is important even in terms of higher influence.

Communities in networks (Estrada & Knight, 2015, Chapter 21) represent an explanation of the organization of nodes in complex networks. Communities are groups of nodes more densely connected amongst themselves than with the rest of the nodes of the network. Communities may be represented by social networks (see Section 2.1.) and may be magnetized by hub-nodes represented by the firm that clusters stakeholders with its gravitational centrality.

The firm is seen as a contract among a multitude of parties (Holmstrom & Tirole, 1989) and this vision is consistent with an interaction of networked stakeholders.

6. THE SPREAD OF INFORMATION (BIG DATA) AMONG NETWORKED STAKEHOLDERS

Communicability accounts for the volume of information transmitted from one node to another in a network by using all possible routes (direct links, paths, trails, etc.) between them. Shorter linking routes are given more weight than longer ones (Estrada & Knight, 2015, Chapter 19).

Information asymmetries – a key concept in corporate governance and a main source of conflicts of interest among stakeholders – arise when communicability is interrupted or non-existent and are more frequent in directed networks, where information flows are not reciprocal between two connected nodes.

Information asymmetries traditionally arise in a corporate governance context where borrowers have better information about their creditworthiness than the lending bank. They originate conflicts of interest which might seriously prevent an efficient allocation of finance: the liquidity allocation problem derives from the fact that although money is abundant, it is nevertheless not easy to give it to the right and deserving borrowers. Managers, for instance, incorporate informative privileges that are discounted with other stakeholders (Myers & Majluf, 1984), increasing the cost of capital and eventually destroying value.

Adverse selection is another typical problem in money lending, and it occurs when banks - not knowing who is who - cannot easily

discriminate between good and risky borrowers, who should deserve higher interest rate charges.

Moral hazard is a classical "take the money and run problem" since borrowers might try to abscond with the bank's money or try not to fully engage them in the project for which they have been financed.

These classical corporate governance problems are well-known in traditional banking and they naturally bring to sub-optimal allocation of financial resources and to capital rationing problems that frequently affect even potentially sound borrowers, if they are not able to differentiate themselves from those who bluff. The theory of signalling states that information asymmetry between a firm and outsiders leads the former to make certain changes in its capital structure. Ross (1977), Myers and Majluf (1984) and John (1987) have shown that under asymmetric information, firms may prefer debt to equity financing.

Information is conveyed through interactive networks and so its representation and analysis is fully consistent with network theory.

The network data that mostly impact on information sharing are represented by the world wide web and the Internet.

While the terms www and the Internet are often used interchangeably in the media, they refer to different systems. The www is an information network, whose nodes are documents and links are URLs. In contrast, the Internet is an infrastructural network, whose nodes are computers called routers and whose links correspond to physical connections, like copper and optical cables or wireless links. The degree distribution of both networks is well approximated by a power law and so these networks are scale-free. In the Internet, a few highly connected hubs hold together numerous small nodes.

Network theory can be linked to big data, especially through digital platforms that convey information in real time. Value chains based on traditional databases become networked when they are linked to other chains through value-adding networks. Value chains networks are more resilient and able to cope with risks of failure, enabling alternatives.
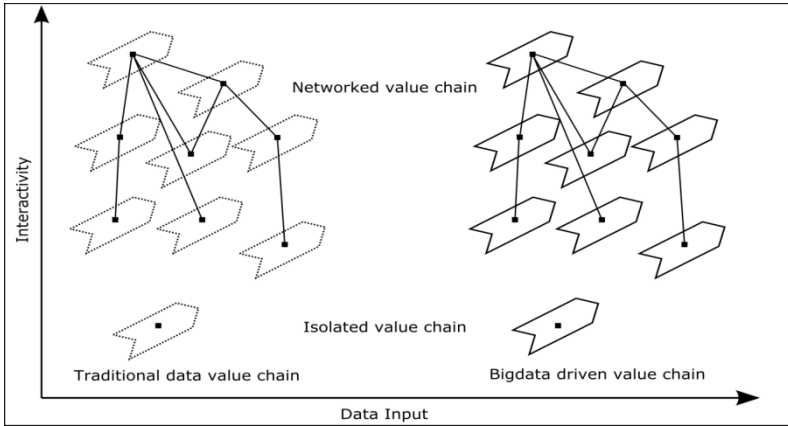
Networked value chains fuelled by big data stand out as the best value maximizing option, as illustrated in Figure 12.

Degree, correlations, clustering, and centrality provide information on single nodes, their immediate surroundings, and their position with respect to the overall network (Caldarelli & Catanzaro, 2012). These features are networked informative nodes. Edging big data correlated to nodes disseminate extensive information in real-time.

The topology of networks, so important for their interpretation, is based on computing the edge betweenness that finds the edges through which most of the shortest paths pass.

Websites and the internet can be interpreted in terms of network science, being represented by relations among vertices and their connecting edges.

Figure 12. Network of value chains

Source: taken from Moro Visconti et al. (2017)

Social networks, continuously fuelled by big data collection and processing, show the dynamic relationships among social entities (persons, groups, etc.). Along the value chain, they particularly develop the sharing phase. Big data processing of social network contents is quite complicated since the wording is semantically hard to interpret and classify.

7. VALUE DESTRUCTION DUE TO (STRATEGIC) NODE DELETION

Whenever a node is deleted (see Section 2.3.), the value is destroyed. If the node is central, due to its strategic importance, its removal may severely impair the firm, up to its possible default.

Destruction or removal of a node may cause cascading implications due to domino effects, especially in bi-directional (undirected) networks where links are one-to-one.

Examples may be given by disappearance of a strategic supplier, default of an important client with economic and financial drawbacks that can undermine the survival chances of the firm, abandonment of key employees and managers (especially in small firms), withdrawal of a big creditor (bank), etc.

The resilience of the firm and its ability to cope with adversities can be measured even in terms of capacity to rebuild the network when key nodes disappear.

Node deletion may disrupt the supply (and the value) chain that after being broken might be re-arranged substituting disappearing nodes or broken links.

8. INTERLOCKING DIRECTORSHIP

A keiretsu (系列), literally system, series, a grouping of enterprises, an order of succession) is a set of companies with interlocking business relationships and shareholdings. It is a type of informal business group. The keiretsu maintained dominance over the Japanese economy for the second half of the 20th century.

Interlocking rotates around corporate centrality, a concept with two components, a large number of interlocks, plus the degree to which those interlocks are with other companies with a large number of interlocks. In the past, banks were invariably the most central organizations in the corporate network (Domhoff, 2016).

Interlocking is fully consistent with a networked representation of related directors that link different firms.

9. INTERNATIONAL GROUP GOVERNANCE: A NETWORKED RATIONALE BEHIND THE MULTINATIONAL FIRM

A multinational corporation is a corporate organization which owns or controls the production of goods or services in at least one country other than its home country.

The rationale of multinational enterprises has long been debated (Contractor, 2012).

A graphical representation of the linked firms, typically with a holding company located in one country and several subsidiaries located elsewhere, is fully consistent with the network theory.

Figure 13. Geographical network of firms belonging to the same group (with an Italian Holding)
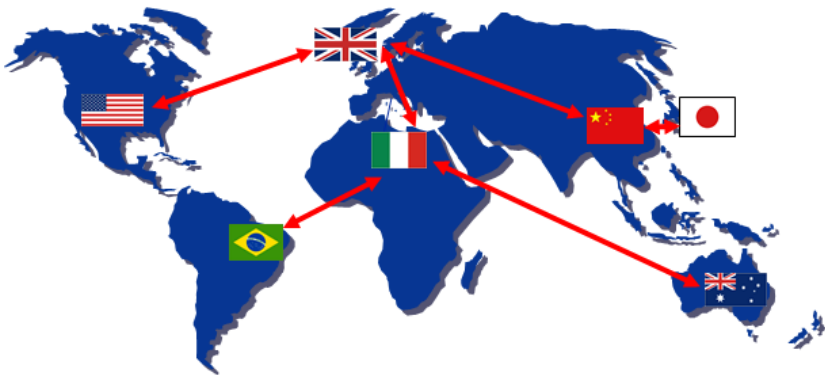
10. SOCIAL NETWORKS AND CROWDFUNDING

A social network is a social structure made up of a set of social actors (such as individuals or organizations), sets of dyadic ties, and other social interactions between actors. The social network perspective provides a set of methods for analyzing the structure of whole social entities as well as a variety of theories explaining the patterns observed in these structures (Wasserman & Faust, 1994). The study of these structures uses social network analysis to identify local and global patterns, locate influential entities, and examine network dynamics.

Crowdfunding is the practice of funding a project or venture by raising small amounts of money from a large number of people, typically via the Internet.

In crowdfunding, a digital platform is a connecting hub among the different equity-holders.

11. GAME THEORETIC NETWORKS AND CORPORATE GOVERNANCE

Network game theory is the combination of network analysis and game theory to the study of situations of interdependence between adaptive agents. Network game theory builds upon and expands classical game theory by incorporating the network of connections – the context – within which agents make their choices, in so doing it potentially offers a richer model of the behavior of agents within games.

Game theory is the study of mathematical models of strategic interaction between rational decision-makers (Aumann, 1987). Game types can be:

a. Cooperative / Non-cooperative

A game is cooperative if the players are able to form binding commitments externally enforced (e.g. through contract law). A game is non-cooperative if players cannot form alliances or if all agreements need to be self-enforcing (e.g. through credible threats).

b. Symmetric / Asymmetric

Asymmetric game is a game where the payoffs for playing a particular strategy depend only on the other strategies employed, not on who is playing them. If the identities of the players can be changed without changing the payoff to the strategies, then a game is symmetric.

c. Zero-sum / Non-zero-sum

Zero-sum games are a special case of constant-sum games, in which choices by players can neither increase nor decrease the available resources. In zero-sum games, the total benefit to all players in the game, for every combination of strategies, always adds to zero (more informally, a player benefits only at the equal expense of others).

d. Simultaneous / Sequential

Simultaneous games are games where both players move simultaneously, or if they do not move simultaneously, the later players

are unaware of the earlier players' actions (making them effectively simultaneous). Sequential games (or dynamic games) are games where later players have some knowledge about earlier actions. This need not be perfect information about every action of earlier players; it might be very little knowledge.

The link between game and network theories is evident, but even the connections with corporate governance can be easily evidenced if the patterns of interaction among different stakeholders are carefully analyzed.

Game theory can improve the interpretation of reciprocal and contractual governance patterns.

Game theory applications to finance discriminate between uninformed and informed agents, with applications to corporate control, capital structure, dividends and stock repurchases, external financing, and financial intermediation (Thakor, 1991). Corporate finance applications concern also the signaling model, agency costs and other key issues (Allen & Morris, 2014) that have strong links with corporate governance concerns.

12. DISCUSSION AND CONCLUSION

Stakeholders represent the founding block of corporate governance and their intricate interactions can intuitively be represented by networks.
Some key questions, however, remain largely unexplored, concerning for instance, what happens around nodes and their links:

- Which are the links that represent the firm's network?
- Which are the hub nodes? The firm itself, and also key stakeholders, etc.
- How strong are the links among different nodes (stakeholders)?
- Which are the dynamics that start from the "photography" of the network to estimate its dynamic trends?

These questions contain tips for future investigation and may ignite new research avenues.

Another trendy issue concerns digital platforms that work as bridging entities among networking stakeholders who use the platform to exchange information. Links among different stakeholders (nodes) vehiculate (big) data, reducing information asymmetries and creating volatile (risky) economic returns. Physical supply chains, digital platforms, and social networks represent interconnected layers to exchange data, make transactions and boost value co-creation and sharing.

A scientific methodology often used in network theory is represented by induction: what can be shown for small networks may be intuitively extended to other networks (Estrada & Knight, 2015, p. 34).

Linkages among different stakeholders can increasingly follow artificial intelligence patterns that are deemed to have deep corporate governance implications (Grove & Lockhart, 2019).

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