The small world phenomenon and assortative mixing in Polish corporate board and director networks

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HIGHLIGHTS

- Both networks are distant to random displaying the small-world properties.
- Both networks are more compact than the classical random graph.
- Both networks display assortative mixing.

ARTICLE INFO

ABSTRACT

This paper investigates the corporate board and director networks in the Polish capital market in 2014. We examined real board and director networks in comparison with networks that were randomly constructed. Through empirical analyses, we demonstrated that the real networks have the characteristics of small-world networks. In addition, the networks are assortative and highly clustered, which imposes certain behaviors on them.
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1. Introduction

Considerable attention has been paid to real world networks, such as corporate board and director networks [1–5]. This assertion also pertains to econophysics [4,6,7]. The analyses in this vein inform us about the organization of business networks, including how information is disseminated and how economic power is concentrated [8–13]. Therefore, in this paper, we will uncover the properties of board and director networks, focusing on investigating the small-world properties [14–16] and assortativity mixing [17] that might determine their behaviors. At the same time, we will try to shed light on the constraints on the interpretation of specific quantities that are inherited from the construction of specific metrics relating to features of the board and director networks.

Analyses of small-world effect in corporate and director networks have been conducted for the US [8,11,12,16,18–22]; UK [19,22]; Australia [21]; Canada [22]; Italy [8,11,20,22]; Germany [19,22]; the Netherlands and Switzerland [22,23]; Denmark, Norway, Sweden [22,24]; South Africa [25]; and Spain, France, Brazil, Chile, Israel, Korea, Mexico, Taiwan [22]. Analyses of assortativity in corporate and director networks have been conducted for the US [11,12,19,20]; Italy [11,20]; UK and Germany [19]; South Africa [25].

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Table 1
Average board size and average number of directorship held in Poland and other countries.

Country (year)	Average board size	Average number of directorship held
Poland (2014)	7.8	1.2
UK (2002) [19]	6.51	1.84
Germany (2008) [26]	13.3	1.12
Germany (2002) [19]	6.33	1.45
Italy (1998–2011) [27]	⟨9.57–10.41⟩	⟨1.20–1.27⟩
Italy (2008) [28]	10.16	1.54
Switzerland (2000) [23]	9.5	–
Netherlands (2001) [23]	8.2	–
US (2003) [19]	9.97	1.63
US (1995) [29]	–	1.6
New Zealand (1993) [30]	6.14	1.22
Australia (1991) [30]	8.37	1.19
South Africa (2008) [25]	8.56	1.28
France (1999) [31]	9.48	–

Entries '–' indicate missing data.

Table 2
Global indicators for the board and director networks.

Variable	Board		Director	
	Entire network	Largest component	Entire network	Largest component
N	903	518	5943	3282
E	1279	1185	26 121	16 336
k	2558	2370	52 242	32 672
$\langle k \rangle$	2.83	4.58	8.79	9.94
Max k	19	19	76	76
Number of pendant nodes	159	88	14	1
N_{LC}/N	57.36%		55.22%	
Number of isolated nodes	265		4	
Number of connected nodes	638		5939	
Inclusiveness	70.65%		99.93%	
c	310		310	
$(c - 1/N - 1)$	0.34		0.05	

N = Number of nodes, E = Number of edges, k = Degree, $\langle k \rangle$ = Mean degree, Max k = Maximum degree, N_{LC}/N = Fraction of vertices in the largest component, c = Number of components, $(c - 1/N - 1)$ = Component ratio.

The paper is organized as follows: Section 2 introduces the characteristics of the data set used in this paper. In Section 3, we inspect the board and director networks from a global perspective. In Section 4, the small-world properties of both networks are investigated. Finally, in Section 5, assortativity is explored. The paper ends with a summary of its conclusions.

2. The data set

We analyzed the composition of corporate board and director networks in Poland in 2014. We obtained corporate board information on the 903 companies listed on the main market at the Warsaw Stock Exchange (461 companies) and on the NewConnect market (442 firms) in October 2014. This data was obtained from Notoria database and checked for consistency. Using this data, we created a corporate board network with 903 vertices/companies and a director network with 5943 vertices. In the *board network*, two vertices (representing boards or companies) are connected by an edge if they have at least one director in common. In the *director network*, when two vertices represent directors who are both members of a particular board, an edge is established between them. When two firms have at least one director in common, the directorates are called interlocking [1]. The two aforementioned networks are undirected and unweighted. The average board of directors in our data set is composed of 7.8 directors and the average director holds 1.2 directorships, which implies that there are interlocking directorates, and it can be compared with other countries (Table 1). Most directors sit on only one board. Out of the 5943 directors, 5224 (approximately 88%) hold only one board position.

3. The global view of the corporate board and director networks: statistical properties

Many indicators have been proposed for characterizing the networks of boards and directors. In an initial inspection, we consider the basic indicators needed to understand the two networks. We report them in Table 2. From a global point of view (Table 2) we first observe that the fraction of the vertices in the largest component, N_{LC}/N, of each network is larger than 0.55. The presence of the largest component prevails in real-world data networks [4,8]. In the case of the corporate board network, the vertices that are not part of the largest component belong to 309 small components, 265 of which consist of one vertex (an isolated vertex). Interestingly, in the director network, the vertices that are not part of the largest component