JEL Classification: G14, G30
Keywords: board centrality, stock return synchronicity

Exploring the Crucial Link between Boardroom Centrality and Stock Price Informativeness

Chyi-Lun CHIOU - Department of Business Administration, Fu Jen Catholic University (clchiou@mail.fju.edu.tw) corresponding author

Pei-Gi SHU - Department of Business Administration, Fu Jen Catholic University

Wen-Hsin TSAI - The Center for Economic Forecasting, Chung-Hua Institution for Economic Research

Abstract

This study examines the information transmission function of board interlocks by analyzing the relationship between board centrality and stock return synchronicity. Using a sample of Taiwanese listed firms from 2007 to 2024, we find a significant positive relationship between board centrality and stock return synchronicity. Board centrality facilitates information transmission among interlocking firms, causing more firm-specific information to be leaked and factored into current prices. This results in less surprise when new information is disclosed in the future. Consequently, market factors should explain more stock returns, leading to higher stock return synchronicity. The role of informativeness is further supported by evidence showing a negative moderating effect of analyst coverage and stock turnover, and a positive moderating effect of group holding. The empirical results remain robust with alternative definitions of centrality measures and considerations of endogeneity. Our findings suggest that the information environment improves with interlocking directorates.

1. Introduction

Networks formed through interlocking directorships play a crucial role in the exchange of information and resources, offering several benefits to interlocking firms. These benefits include the formation of strategic alliances (BarNir & Smith, 2002; Brunninge, Nordqvist, & Wiklund, 2007), improved firm performance (Horton, Millo, & Serafeim, 2012; Larcker, So, & Wang, 2013), access to external finance (Javakhadze & Rajkovic, 2019), enhanced investment efficiency (Intintoli, Kahle, & Zhao, 2018), and better credit ratings (Benson, Iyer, Kemper, & Zhao, 2018). However, there are also potential downsides to board networks, such as the adoption of poison pills (Davis 1991), option backdating (Bizjak, Lemmon, & Whitby, 2009; Janney & Gove, 2017), earnings management (Chiu, Teoh, & Tian, 2013), and stock exchange switching (Rao, Davis, & Ward, 2000).

In this study, we argue that interlocking boards improve the information environment by accelerating the dissemination and accessibility of firm-specific

https://doi.org/10.32065/CJEF.2025.03.03

The authors would like to thank the anonymous referees for their valuable comments and suggestions. We appreciate the National Science and Technology Council (110-2410-H-030-024-MY2) for the financial support. Any mistakes or omissions are solely the responsibility of the authors.

information. Well-connected boards gain early access to reliable internal information and create opportunities for market participants to learn about a company's operating decisions and practices (Intintoli et al., 2018; Mizruchi, 1996). Importantly, some critical private information may also leak within the interlock network (Chiu et al., 2013), which, when disseminated, allows market participants to make more accurate predictions about firm-specific events. In efficient markets, this information is quickly incorporated into stock prices, reducing the impact of firm-specific events on returns when disclosed later (Dasgupta, Gan, & Gao, 2010).

This study examines how board interlock networks influence the information environment, focusing on the relationship between board centrality and stock return synchronicity. This area has been minimally explored in prior research, making an understanding of the relationship essential. Board centrality, as described by social network theory, reflects the degree of a board's connectedness and a firm's position within the network. Interlocking boards provide channels for sharing information and knowledge across firms (Pfeffer & Salancik, 2015), facilitating the transfer of information and experiences (Galaskiewicz & Wasserman, 1989; Haunschild & Beckman, 1998). Board interlocks help reduce information asymmetry by enabling the exchange of internal information, which enhances investment efficiency (Zhao, 2021) and improves the overall information environment.

We propose two mechanisms through which board interlocking affects stock return synchronicity. The first is the monitoring channel, which suggests that connected boards improve the information environment, reducing information asymmetry and leading to higher stock return synchronicity. The second is the informed trading channel, which posits that board networks facilitate informed trading, accelerating the incorporation of information into stock prices and reducing the amount of information left to be factored in later. These channels suggest that firms with more board interlocks are more likely to have firm-specific information fully reflected in current stock prices, resulting in higher stock return synchronicity.

The monitoring argument suggests that interlocking boards improve business practices and the information environment. Firms can learn from connected companies' experiences, with research showing that board interlocks lead to higher voluntary disclosures (Chan, Lee, Petaibanlue, & Tan, 2017), better financial reporting (Intintoli et al., 2018), and more accurate forecasts (Ke, Li, & Zhang, 2020). These practices spread through interlocks, aiding decision-making and strategy development. Transparent information environments allow market participants to quickly incorporate firm-specific information into stock prices, reducing market surprises and boosting stock return synchronicity.

The informed trading channel, as proposed by Cheng, Felix, and Zhao (2019), suggests that board interlocks also increase the likelihood of informed trading. Board connectedness provides directors with access to private information, which can be used for informed trading. Previous studies have shown that possessing private information increases the probability of informed trading (Khan & Lu, 2013). Cheng et al. (2019) find that firms with better board interlock networks experience more informed short-selling, suggesting that information leakage from board interlocks accelerates the incorporation of firm-specific information into stock prices, further increasing stock return synchronicity.

Dasgupta et al. (2010) suggest that increased transparency is linked to both time-varying and time-invariant firm-specific information disclosure. Greater transparency allows for the early disclosure of time-varying firm events and facilitates learning about time-invariant characteristics. Their findings show that as new information is incorporated into stock prices, the variation in stock returns decreases over time. Chan, Hameed, and Kang (2013) and Chan and Chan (2014) confirm that high stock return synchronicity is linked to greater liquidity and analyst coverage, suggesting that synchronicity reflects the informativeness of stock prices.

This study explores the relationship between board centrality and stock return synchronicity using data from 29,485 firm-year observations of Taiwanese-listed firms from 2007 to 2024. We find a significant positive relationship between board centrality and stock return synchronicity. The positive linkage arises from the speed of information transmission, where central boards expedite the spread of information among interlocking firms, ensuring that firm-specific information is reflected in stock returns quickly, thus increasing stock return synchronicity.

We also find that analyst coverage and stock turnover negatively moderate this relationship, while group holding positively moderates it. This suggests that board centrality plays a critical role in the speed of information transmission, and when analyst coverage and stock turnover are high, their impact on transparency and synchronicity is less significant. Conversely, group holdings, which reflect ownership complexity and lower transparency, further emphasize the role of board centrality in enhancing information flow and synchronicity.

We choose the Taiwanese stock market for its unique characteristics: political risks stemming from US-China tensions,[1] a high proportion of individual investors who lack the analytical capacity of institutional investors,[2] and the prominence of the semiconductor industry, which has garnered international attention.[3] These factors make Taiwan an ideal setting for studying stock return synchronicity.

Our findings align with related studies on information leakage, such as Brockman and Yan (2009), who found that blockholders increase the likelihood of informed trading and idiosyncratic volatility, and Khanna and Thomas (2009), who showed a positive correlation between board interlocking and stock synchronicity due

[1] According to Morck et al. (2000), political events could cause large market-wide stock price swings, resulting in a high stock price synchronicity

[2] Individual investors continue to represent the most significant proportion of participants in Taiwan's stock markets. According to Taiwan Stock Exchange statistics, in the first quarter of 2024, individual investors accounted for 55.24% of the total trading volume in the centralized market. Foreign investors contributed 32.36%, while domestic institutional investors made up 12.40%.
Compared to institutional investors, individual investors typically have less sophisticated investment experience and fewer resources for gathering and analyzing value-relevant information. Because they tend to hold more minor stock positions and trade more frequently, they play a less active role in monitoring market activities. As a result, managers enjoy greater flexibility in setting information disclosure policies (An & Zhang, 2013).

[3] The semiconductor industry, which includes Integrated Circuit (IC) manufacturing, design, and packaging, is a key pillar of Taiwan's IT sector. Taiwan has positioned itself as a global leader in microchip production, driven by its advanced OEM wafer manufacturing capabilities and robust supply chain. As a result, the semiconductor sector in Taiwan is valued at approximately US$115 billion, representing around 20% of the global market. Notably, Taiwanese companies dominate the foundry sector, holding 50% of the global market share, with Taiwan Semiconductor Manufacturing Company (TSMC) leading as the largest player in the industry.

to reduced transparency. However, unlike their use of pairwise interlocks, we employ comprehensive board centrality measures to capture the linkage among interlocking firms.

This study contributes to the literature in several ways. It fills a gap by exploring the relationship between board centrality and the information environment, complementing research on centrality's links to strategic alliances (BarNir & Smith, 2002), firm performance (Horton et al., 2012), investment efficiency (Intintoli et al., 2018), and other outcomes. We establish a positive relationship between board centrality and stock return synchronicity, showing that central boards accelerate the transmission of firm-specific information, leading to higher synchronicity.[4] Our findings also highlight the moderating effects of analyst coverage, stock turnover, and group holdings, reinforcing the importance of information transmission speed in shaping stock return synchronicity. Furthermore, interlocking boards help firms adopt similar strategies, leading to greater market comovement.

The rest of this paper is organized as follows. Section 2 is the literature review and hypothesis development. Section 3 depicts the data, variables, and empirical models. Section 4 reports the empirical findings. Section 5 is robustness checks. Section 6 is further discussion. Section 7 concludes.

2. Literature Review and Hypothesis Development

2.1 Board Centrality

Board networks provide an important conduit for information exchange among interlocking firms. Through information exchange, interlocking firms receive benefits such as strategic alliances (BarNir & Smith, 2002; Brunninge, Nordqvist, & Wiklund, 2007), an enhancement in firm performance (Horton, Millo, & Serafeim, 2012; Larcker, So, & Wang, 2013), investment efficiency (Intintoli, Kahle, & Zhao, 2018), credit ratings (Benson, Iyer, Kemper, & Zhao, 2018), and growth opportunities and innovations (Ahuja, 2000; Tsai & Ghoshal, 1998), and the access to external finance (Javakhadze & Rajkovic, 2019). Nevertheless, there are dark sides associated with board networks, including poison pill adoption (Davis, 1991), option backdating (Bizjak, Lemmon, & Whitby, 2009; Janney & Gove, 2017), earnings management (Chiu, Teoh, & Tian, 2013), and stock exchange switching (Rao, Davis, & Ward, 2000). Specifically, Tao, Li, Wu, Zhang, and Zhu (2019) find that firms with greater board centrality tend to engage in value-destroying mergers and acquisitions. These interlocking directors take advantage of their connections for private benefits while at the expense of shareholder wealth.

A common approach to characterizing board interlocking is through the concept of centrality borrowed from social network studies. Prior studies such as board

[4] Two main views connect informativeness to stock return synchronicity. One suggests a positive relationship—faster information incorporation increases R^2, indicating greater price informativeness (e.g., Kelly, 2014; Dasgupta et al., 2010). The other contends that higher R^2 reflects less firm-specific information, so greater firm-level information reduces synchronicity (e.g., Morck et al., 2000). Our findings support the former in the context of Taiwan's retail-dominated market, where board centrality enhances synchronicity through monitoring and informed trading.

interlock networks and venture capital networks (Davis & Greve, 1997) imply that network centrality per se is a multi-dimensional construct. Besides degree centrality, other centrality measures could capture the quality of board connectedness (i.e., eigenvector centrality and closeness centrality) and intermediation between two other boards (i.e., betweenness centrality). Degree centrality (DEG) measures the total number of direct linkages a firm has. It is a simple measure of board connectedness. If a firm is more connected, it presumably has more information channels. Closeness centrality (CLOSE) accounts for a firm's direct and indirect links. It measures how quickly one firm's information can be disseminated through the interlock network via direct and indirect links. Eigenvector centrality (EIGN), a refinement of degree centrality (Larcker et al., 2013), captures both the quantity and the quality of a firm's ties because it weights a firm's ties by the importance of those firms to which the firm is tied (e.g., Bonacich, 1987, 2007; Hochberg, Ljungqvist & Lu, 2007).[5] Therefore, being linked to other well-connected firms also enhances the centrality of the firm. In interlock networks, a well-connected firm with high eigenvector centrality suggests that its information could spread faster through the interlock network because its interlocking firms are also well-connected.

2.2 Stock Return Synchronicity

Stock return synchronicity refers to the extent to which stocks move together. In the beginning, why do stock prices move together? Barberis, Shleifer, and Wurgler (2005) propose theories to account for the comovement in stock prices. The conventional theory indicates that price synchronicity reflects comovement in fundamentals in a perfect market where the market is frictionless and investors are fully rational. However, in economies with frictions or irrational investors, comovement in prices could be delinked from comovement in fundamentals. It could be due to simplifying portfolio decisions. For example, Barberis and Shleifer (2003) indicate that many investors group assets into categories and then allocate funds at the level of categories rather than at the individual level. If some of these investors are noise traders with correlated sentiments, these groups of stocks move in the same direction. Alternatively, many investors trade only a subset rather than all available securities. Such preferred habitats may arise because of transaction costs, trade restrictions, or lack of information. The comovement in stock prices sustains because these investors hold and trade these stocks in the preferred habitat.

In this study, we explore the relation between board centrality and stock return synchronicity. First of all, if board centrality implies the control of information flows (Larcker et al., 2013), firms with high board centrality could potentially capture and

[5] Eigenvector centrality considers not only the number of connections a board member has, but also the quality or importance of the board members they are connected to. In simpler terms, a board member with high eigenvector centrality is connected to other well-connected board members. The idea is that being connected to influential or important board members enhances the influence of the board member in question, even if they may not have many direct connections. For example, board member A has connections with board members B, C, and D. However, board member B is relatively well-connected to several influential people, while C and D are less connected. In terms of calculation, eigenvector centrality is computed by solving the equation $\lambda x = xA$ where x is the vector of centralities; A is the adjacency matrix of the network; λ is a constant called the eigenvalue. The better choice for λ is the largest eigenvalue for the matrix of absolute values of A.

control the information flows and the spread of strategic moves and business practices among interlocking firms. If the spread of strategic moves and business practices results in comovement of fundamentals among interlocking firms, firms with high board centrality should exhibit a high degree of stock return synchronicity.

Secondly, if board centrality also implies the transmission of firm-specific information, and with the leaked information, insiders could engage in arbitrage so that the firm-specific private information is likely to be incorporated into stock price. If this is the case, the level of comovement is expected to be higher. Specifically, two questions must be further explored: (1) whether well-connected directors would reveal firm-specific information via social networks? and (2) whether insiders having the private information would engage in arbitrage? Regarding the first question, Cheng, Felix, and Zhao (2019) propose two competing views: the network view and the governance view. The network view (e.g., Akbas et al., 2016) indicates that a well-connected board increases opportunities for leaking nonpublic information through the network, leading to increased informed trading. If this is the case, the firm-specific information could be leaked to others in networks of board interlocking. Alternatively, from the governance view, board connectedness mainly reflects the reputation capital of a board's director in the director labor market (e.g., Shivdasani, 1993; Vafeas, 1999; Yermack, 2004). The reputation capital serves as a strong governance mechanism to mitigate agency problems (e.g., Fama, 1980), including intentional leakage of firms' privileged information. Moreover, better-connected directors opt not to reveal firm-specific information to preserve the private benefit embedded in the network. Better-connected directors are less likely to leak proprietary information if this is the case.

Regarding the second question of whether insiders, when getting proprietary information, would engage in informed trading, related papers indicate that they do. Brockman and Yan (2009) posit that blockholders have a comparative advantage in information precision and a low acquisition cost of private information. They find that blockholders facilitate the probability of informed trading and idiosyncratic volatility increases. Cheng et al. (2019) find that firms with better-connected boards experience higher levels of informed short selling. Moreover, this positive association between interlock centrality and informed trading is more pronounced for firms whose directors can interact with directors of external firms in the network.

We posit that board centrality is positively correlated with stock return synchronicity. The reasons are elucidated as follows. First, interlocking directors facilitate the speed of information transmission among involved firms. The stock returns of these interlocking firms tend to comove because most firm-specific information has been largely incorporated into stock prices, leaving little space for stock returns to be affected by the arrival of new firm-specific information. Second, if the governance view prevails, indicating that interlocking directors are reluctant to leak firm-specific information due to the concern of preserving their personal reputational capital or to the concern of follow-on litigation risks, the stock returns might also comove. This is because interlocking directors share business practices but not firm-specific proprietary information. The shared business practices also lead to the comovement of the firm's fundamentals and, therefore, a higher level of stock return synchronicity. Third, from an investor's perspective, information could be costly to collect and, therefore, focus on a subset of assets. Veldkamp (2006) indicates when information production has high fixed costs, competitive producers charge more for

low-demand information than for high-demand information. Therefore, high-demand information is charged a lower price and is preferred by investors. If these investors focus on a common subset of high-demand information, news about one asset affects the other assets' prices so that their asset prices comove. Under this premise, the information flows via interlocking directorship reduce investors' information searching costs for the connected firms, which enhances investors' demand for firms in the subset so that the stocks in the subset comove. The three arguments boil down to predicting a positive relation between board centrality and stock return synchronicity.

Hypothesis 1: Board centrality is positively correlated with stock return synchronicity.

2.3 Moderator Effect

The core argument of our paper elucidates that board centrality speeds the information transmission and leads to a high level of stock return synchronicity. We introduce three variables of information transparency to moderate the positive centrality-synchronicity relation: analyst coverage, stock turnover, and group holding. Analyst coverage and stock turnover are positive manifestations of information transparency, while group holding is a negative manifestation of information transparency. The derivation of these moderator effects is elaborated as follows.

2.3.1 The Impact of Analyst Coverage

The conventional theory proposes that analysts produce firm-specific and industry- and market-wide information. Two factors affect the type of information they provide: information-gathering and -processing costs, as well as competition among other analysts. Accordingly, Crawford, Roulstone, and So (2012) find that analysts produce industry- and market-wide information when initiating coverage. When more and more analysts join and issue forecast reporting for the same target company, they are forced to generate more firm-specific information to retain their professional reputation. Choi and Gupta-Mukherjee (2022) indicate that analysts use industry- and firm-specific information to form their earnings forecasts. However, due to attention constraints in acquiring and studying costly information, analysts produce more firm-specific information when they face more competition, large firms, and firms with high trading volume and institutional ownership. Therefore, analysts play two important roles in enhancing the informativeness of their covered firms: searching for private information and interpreting publicly available information to investors (Chen, Cheng, & Lo, 2010). The role of analysts in information discovery may enhance the oversight of financial reporting. Yu (2008) finds that analyst coverage is negatively correlated with the level of discretionary accruals, suggesting that analyst coverage may play a monitoring role in constraining managerial opportunism. Hong, Lim, and Stein (2000) indicate that more analyst coverage is negatively correlated with information uncertainty. In this regard, we would expect analyst following to be positively correlated with stock return synchronicity.

How does analyst coverage moderate the positive centrality-synchronicity relation? The relation between board centrality and stock return synchronicity lies in the hinge of information transmission. Moreover, the relation between analyst coverage and stock return synchronicity also lies in the hinge of informativeness. Frankel and Li (2004) also address the fact that analysts can erode the informational advantage of insiders and institutions. Since the two are conceptually redundant, we propose the substitution effect between board centrality and analyst coverage. That is when board interlocking could effectively enhance the speed of information transmission among interlocking firms, analysts are less critical in enhancing informativeness, and vice versa. We, therefore, expect that analyst coverage negatively moderates the positive centrality-synchronicity relation.

Hypothesis 2: Analyst coverage negatively moderates the positive centrality-synchronicity relation

2.3.2. The Impact of Stock Turnover

Turnover is a measure of the firm's trading activity. An actively traded firm is more likely to incorporate both market- and firm-specific information into its prices. Brockman and Yan (2009) find that stock turnover ratio positively correlates with stock return synchronicity, suggesting that active trading helps incorporate more industry-specific information into stock prices. Following this thread of thinking, we expect a positive relation between stock turnover and stock return synchronicity.

Since board centrality and stock turnover affect stock return synchronicity via the hinge of information transmission, it is reasonable to infer that the two are substitutes. That is when information is effectively transmitted via board interlocking among involved firms, the marginal contribution of stock turnover on informativeness is on the wane, and vice versa.

Hypothesis 3: Stock turnover negatively moderates the positive centrality-synchronicity relation

2.3.3 The Impact of Group Holding

Controlling groups could gain control rights via individual holding and group holding. Group holding denotes the complex arrangement via the holding by unlisted firms, funds, and listed firms under their control. The complex arrangement facilitates ownership concentration by controlling owners. Fan and Wong (2002) indicate that concentrated ownership is associated with low levels of transparency and disclosure quality. They argue that concentrated ownership tends to be associated with pyramidal and cross-holding structures, which create agency conflicts between controlling owners and outside investors. The informativeness of reported earnings is adversely affected by self-interested purposes of controlling owners on the one hand and the prevention of leaking proprietary information on the other.

In the case of Korea, Jung and Kwon (2002) indicate that controlling groups use holdings of family and related companies to extend control over many companies in different industries and, therefore, form a corporate group called chaebol. Moreover, these controlling owners tend to directly or indirectly participate in the management of firms and influence most of the management decisions. The involvement of management is associated with a lack of transparency and credibility.

In this study, we use group holding as a negative indicator of informativeness and expect a negative relation between group institutional holding and stock return synchronicity. Moreover, since group holding is detrimental to informativeness, the role of board centrality that speeds the information transmission among interlocking firms would be more critical in affecting stock return synchronicity. We, therefore, expect group holding to positively moderate the positive centrality-synchronicity relation.

Hypothesis 4: Group holding positively moderates the positive centrality-synchronicity relation

3. Data, Variables, and Models

3.1 Data

Our data is collected from the Taiwan Economic Journal (TEJ), a data company in Taiwan. Financial firms that are subject to different regulations are excluded from the sample. The final sample consists of 29,485 firm-year observations in the sampling period of 2007–2024. The sample distribution with yearly and industry breakdown, summarized in Table 1, shows that the number of listed firms exhibits an apparent increase from 1,234 in 2007 to 1,997 in 2024. For the industry breakdown, we find that the electronic components industry comprises most of the sample (3,673, 12.46%), followed by the semiconductor industry (2,717, 9.21%) and the optoelectronic industry (2,392, 8.11%). Taiwan is noted for its high-tech industries, including electronic components, semiconductors, computer peripherals, communication networks, electronic channels, information services, optoelectronics, and other electronics. These firms, in total, comprise 50.85% of the sample.

3.2 Variables

In this section, we introduce the variables. We note that all continuous variables are winsorized at the 1% and 99% levels to mitigate the impact of outliers. Moreover, the independent variables and control variables are lagged one period to mitigate the potential endogeneity problem.

Table 1 Sample Distribution by Year and Industry

code	Year									
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	8	7	7	7	7	7	7	7	7	7
2	40	39	41	41	42	42	41	42	42	43
3	12	12	11	11	11	12	12	12	12	12
4	15	15	15	16	16	17	19	21	23	26
5	75	77	75	75	77	77	79	80	80	79
6	21	21	22	22	23	23	24	25	27	25
7	17	19	18	19	20	23	29	32	35	38
8	23	24	24	23	23	25	28	29	31	31
9	24	25	25	25	25	24	27	27	27	30
10	97	92	85	85	88	94	99	101	105	112
11	34	33	34	37	39	40	41	43	43	43
12	39	43	46	50	60	71	91	108	120	131
13	12	13	13	13	13	13	13	13	13	12
14	106	121	122	126	141	146	141	147	149	159
15	93	98	95	101	101	101	101	105	107	106
16	81	96	102	105	128	150	152	150	154	150
17	61	64	65	66	67	71	76	80	82	92
18	158	174	177	184	192	202	208	212	218	215
19	44	45	44	44	43	42	42	40	40	39
20	24	24	23	23	23	24	24	24	25	25
21	33	33	31	29	29	31	30	30	33	33
22	61	69	68	71	76	79	83	81	81	81
23	14	15	16	16	18	19	22	24	30	33
24	1	1	1	1	1	1	1	1	3	7
25	2	2	2	2	2	3	4	5	6	6
26	50	49	49	49	49	51	51	52	53	53
27	62	63	62	60	61	61	68	73	80	83
28	16	15	14	14	15	16	16	17	17	17
29	4	4	4	4	4	4	4	5	6	6
30	7	7	7	7	7	7	7	7	7	7
sum	1234	1300	1298	1326	1401	1476	1540	1593	1656	1701

Table 1 Sample Distribution by Year and Industry Continued

code	Year								
	2017	2018	2019	2020	2021	2022	2023	2024	sum
1	7	7	7	7	7	7	7	7	127
2	45	46	46	47	48	49	49	51	794
3	12	13	13	13	13	12	11	11	215
4	28	29	31	31	34	34	34	35	439
5	79	78	78	77	79	86	86	85	1422
6	26	26	28	29	29	28	29	32	460
7	46	45	46	47	51	51	55	54	645
8	32	34	36	36	38	20	19	19	495
9	30	30	31	29	29	30	30	33	501
10	119	124	136	139	144	179	187	194	2180
11	47	47	49	49	47	43	46	47	762
12	146	158	166	169	177	179	187	197	2138
13	12	12	12	13	13	13	13	13	229
14	157	159	161	165	171	174	184	188	2717
15	105	111	112	116	115	112	115	117	1911
16	144	147	145	142	141	135	135	135	2392
17	92	92	92	92	94	94	96	96	1472
18	218	214	214	218	220	213	217	219	3673
19	39	37	37	37	37	37	39	39	725
20	25	24	25	25	25	25	25	25	438
21	33	35	38	42	44	42	48	47	641
22	81	84	87	91	91	89	92	97	1462
23	38	39	42	40	42	39	34	34	515
24	9	8	9	7	7	6	4	5	73
25	8	8	7	8	9	18	21	26	139
26	53	54	53	53	53	51	51	52	926
27	88	91	103	107	110	104	109	111	1496
28	16	16	15	17	17	16	16	16	286
29	6	6	5	5	5	5	5	5	87
30	7	7	7	7	6	7	7	7	125
sum	1748	1781	1831	1858	1896	1898	1951	1997	29485

3.2.1 Stock Return Synchronicity

A direct measure of return synchronicity is the variation of stock return explained by the four-factor asset price model of Carhart (1997) as follows. The attractiveness of the four-factor model lies in the fact that it allows individual stock to have distinct betas with respect to risk factors, reflecting the variation in stock return synchronicity. The multiple-factor model is also beneficial for capturing the variation in the association between centrality and synchronicity in terms of different betas (Chue, Gul, & Mian, 2019).

$$r_{i,d} = \beta_0 + \beta_{mkt,i} MKT_d + \beta_{SMB,i} SMB_d + \beta_{HML,i} HML_d + \beta_{UMD,i} UMD_d + \varepsilon_{i,d} \quad (1)$$

where $r_{i,d}$ denotes the return of stock i on day d and the explanatory variables are the standard Fama-French three factors of market (MKT), size (SMB), and value (HML) plus the momentum (UMD) factor. The coefficient of determination, R2, of Eq. (1) is a measure of synchronicity between the stock's return and the factor returns based on daily return observations of the year.[6]

Initially, the measure of R2 is bounded between zero and one and exposes the risk of significant skewness and kurtosis when conducting conventional regression analysis. We refer to Morck, Yeung, and Yu (2000) and Jin and Myers (2006) and apply a logistic transformation of raw R2. Our measure of stock return synchronicity (SYNCHi,t) for stock i in year t is redefined as follows. The average R2 is 0.220 while the average synchronicity is –1.631:

$$SYNCH_{i,t} = \ln\left(\frac{R^2_{i,t}}{1 - R^2_{i,t}}\right) \quad (2)$$

3.2.2 Centrality Measures

The data of board interlocking is jointly collected from the module of directors' educational and working experiences and the module of directors' shareholdings from TEJ. The calculation of centrality measures is via importing data from TEJ to the package from the UCI website

[6] The advantages of measuring synchronicity using R^2 are as follows. First, our use of R^2 as the measure of stock return comovement aligns with previous studies (Morck et al., 2000; Chan & Hameed, 2006; Jin & Myers, 2006; Dasgupta et al., 2010; Gassen, Skaife, & Veenman, 2020). Second, while alternative measures such as simple correlations, conditional correlations accounting for market heterogeneity (Forbes & Rigobon, 2002), dynamic conditional correlations (Engle, 2002), and exceedance correlations addressing extreme market risks (Boyer, Kumagai, & Yuan, 2006) have been widely used in prior studies, Morck et al. (2000) suggest that R^2, which relates firm-specific stock price movements to market-wide price movements, is preferred. This is because other measures that consider pairwise relationships can become cumbersome to calculate when the number of assets exceeds 150, and their significance is lower compared to market-wide R^2.

(https://sites.google.com/site/ucinetsoftware/downloads). There are several measures of centrality. The first one is degree centrality (DEG) which measures the total links to connected firms via board interlocking.

$$DEG_i \equiv \sum_{j \neq i} \delta(i,j) \tag{3}$$

where $\delta(i,j)$ denotes an indicator that firm i and j are linked. The summary statistics in Table 2 show that, on average, the Taiwanese listed firms connect 5.417 firms via interlocking boards.

The second one is the closeness centrality measure (CLOSE), which measures how easily a firm reaches other firms in a network. We define CLOSE as follows.

$$CLOSE_i \equiv \frac{n-1}{\sum_{j \neq i} l(i,j)} \tag{4}$$

where $l(i,j)$ denotes the shortest path between firm i and j. To be consistent with other centrality measures, we modify CLOSE as the inverse value of the average distance of these shortest paths. We note that the $l(i,j)$ is set at the longest path plus one when firm i and j are disconnected via board interlocking.[7] Therefore, with the inverse transformation, the higher the measure of closeness centrality, the higher the control of information flows.

The third one is eigenvector centrality (EIGN), which, in reference to Bonacich (1987), measures a firm's importance in terms of the centrality of its neighbors. In particular, this measure assumes that the centrality of a firm in terms of power and prestige is proportional to the centrality of its neighbors.

$$\lambda \times CENTRALITY \equiv \sum_j g_{i,j} \times CENTRALITY_j \tag{5}$$

where λ is the proportionality factor and $g_{i,j}=1$ if firms i and firm j are interlocked. Writing (5) in vector form, we can see that each firm's centrality can be obtained by the EIGENVECTOR of the matrix G. The statistics show that the average eigenvector centrality of our sampling firms is 0.0066.

$$\lambda \times EIGENVECTOR = G \times EIGENVECTOR \tag{6}$$

The fourth one is betweenness centrality (BTWN, Freeman, 1977), which measures how important or well-situated a firm is in connecting other firms to each other.

[7] According to the setting of parameters for closeness measure in UCI, there are three types: the sum of geodesic distances (Freeman), the sum of reciprocal distance, and the average of reversed distances.

$$BTWN_i \equiv \sum_{j \neq i : i \notin (k,j)} \frac{P_i(k,j)/P(k,j)}{(n-1)(n-2)/2} \tag{7}$$

where $P_i(k,j)$ denotes the number of shortest paths between firm k and firm j that firm i lies on, and $P(k,j)$denotes the total number of shortest paths between firm k and firm j, then for a firm i in the network. The average betweenness measure is 2,868.

Finally, because each of the four centrality measures captures different aspects of a firm's importance in a network, we construct an aggregate centrality measure (NScore) as follows.

$$NScore \equiv \frac{1}{4}\left(r_{DEG} + r_{CLOSE} + r_{BTWN} + r_{EIGN}\right) \tag{8}$$

where $r_{DEG}, r_{CLOSE}, r_{BTWN}, r_{EIGN}$ denote the rank score of firms being classified into deciles based on degree centrality, closeness centrality, betweenness centrality, and eigenvector centrality, respectively.[8] The average rank score for the aggregate centrality measure is 0.550.

3.2.3 Moderators

We introduce three moderating variables to the centrality-synchronicity relation. The first one is analyst coverage which is the number of analysts following a particular stock (Analyst). The average analyst coverage is 6.394. The second moderator is turnover (Turnover), which is defined as the total trading volume divided by outstanding shares. The average turnover ratio is 165.0%. The third moderator is group holding (Groupholding), which is defined as total shareholding by legal institutions (listed firms, unlisted firms, and funds) under the control of the controlling owner. The average group holding is 20.91%. We note that analyst coverage and turnover ratio are positive indicators of informativeness, while group holding is negative.

3.2.4 Control Variables

The selection of control variables is in tandem with prior studies (e.g., Dasgupta et al., 2010; Ho & Michaely, 1988; Chemmanur & Fulghier, 1999). Since these variables are likely to influence firms' information environment and their board connectedness, controlling impacts from these variables can ensure that our result is not driven by any of these properties and mitigate endogeneity bias. The first one is size (Size), defined as the natural logarithm of the market value of assets. Large firms tend to comove with the market more than small ones (e.g., Piotroski & Roulstone, 2004; Gul et al., 2011). We, therefore, expect a positive relation between the firm's size and stock return synchronicity. The average market value of assets is NT$11,915 million (equivalent to US$372 million). The second control variable is leverage (Leverage). Prior studies indicate that leverage increases a firm's idiosyncratic risk

[8] Moreover, we employ both original and standardized centrality measures in the empirical analysis. The (unreported) results show that centrality remains positively correlated with stock return synchronicity.

(Abdoh & Varela, 2017) and incorporates more firm-specific information (e.g., Ferreira & Laux, 2007; Dasgupta et al., 2010; Sila et al., 2017), and therefore lowers stock return synchronicity. The average financial leverage is 41.4%.

The third control variable is ROA. Firms with higher profitability are likely to have lower stock price informativeness (Ben-Nasr & Cosset, 2014; Gul et al., 2011). ROA could be negatively correlated with stock return synchronicity if this is the case. The average ROA of the listed firms is 7.941%. The fourth one is the market-to-book (MB) ratio, which is defined as the natural logarithm of the ratio of the market value of equity over the book value of equity. A high market-to-book ratio is considered a high risk to deter investors and deteriorate the information environment. As a result, a negative relationship between market-to-book ratio and stock return synchronicity is expected. The average market-to-book ratio is 1.924.

The fifth control variable is the firm's age (Age). As firm ages, the market learns more about time-invariant firm characteristics (e.g., the firm's intrinsic quality). Therefore, a firm's age is supposed to be positively correlated with its stock return synchronicity. The average months of age for our sampling firms is 334.4. The final control variable is an indicator variable (Crossholding) representing a firm's cross-shareholding status, which equals 1 for a firm with cross-shareholding and equals 0 otherwise. Wen, Yuan, and Zhou (2021) indicate that price informativeness is associated with ownership structure. Their finding suggests that the information environment improves with cross-shareholding, leading to higher stock return synchronicity due to fewer pricing errors or noise trading in the marketplace. The average Crossholding of the sample is 0.189, implying that more than 18% of observations possess cross-shareholding conditions.

To test the effect of board centrality on stock return synchronicity, we adopt the following baseline model in the fixed effect regression analysis. We control for the firm- and year-fixed effect and use standard errors clustered at the firm level. The design of one period lag between independent variables and control variables is for mitigating the potential endogeneity problem and capturing the dynamic response of return synchronicity to an improvement in the information environment.

$$SYNCH_{i,t+1} = \beta_0 + \beta_1 Centrality_{i,t} + \sum_j \delta_j Control_{i,t} + \gamma_i + \sum_t Year_{t+1} + \varepsilon_{i,t+1} \qquad (9)$$

where control variables include the natural logarithm of firm size, leverage, ROA, market-to-book ratio, the natural logarithm of age, and crossholding. We include γ_i and year dummies to control firm and yearly fixed. $\varepsilon_{i,t+1}$ represents the unspecified random factors.

Table 2 Summary Statistics

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	***N***	***Mean***	***S.D.***	***Q1***	***Median***	***Q3***
Dependent						
SYNCH	29,485	-1.631	1.246	-2.369	-1.382	-0.713
R^2	29,485	0.220	0.156	0.0855	0.201	0.329
Main Variables						
DEG	29,485	5.417	5.503	1	4	8
CLOSE	29,485	298.8	180.0	231.5	362.9	428.6
EIGEN	29,485	0.0066	0.0162	2.21e-05	0.0008	0.0048
BETW	29,485	2,868	4,545	0	912.2	3,776
NScore	29,485	0.550	0.261	0.325	0.525	0.775
Alternative measures						
DEG_cross	29,485	4.745	5.046	1	3	7
CLOSE_cross	29,485	246.7	151.0	182.6	296.0	356.7
EIGEN_cross	29,485	0.0065	0.0168	5.16e-07	0.0005	0.0041
BETW_cross	29,485	2,285	3,869	0	413.8	2,996
NScore_cross	29,485	0.550	0.258	0.300	0.525	0.775
DEG_nonm	29,485	4.841	5.237	1	3	7
CLOSE_nonm	29,485	278.3	163.6	229.3	332.0	394.8
EIGEN_nonm	29,485	0.0055	0.0184	0	0.0002	0.0028
BETW_nonm	29,485	2,815	5,079	0	634.2	3,528
NScore_nonm	29,485	0.550	0.255	0.325	0.525	0.750
Control Variables						
MV(Million NTD)	29,485	11,915	33,551	1,170	2,803	7,831

Table 2 Summary Statistics Continued

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	***N***	***Mean***	***S.D.***	***Q1***	***Median***	***Q3***
Size (lnMV)	29,485	8.087	1.455	7.065	7.938	8.966
Leverage	29,485	0.414	0.185	0.273	0.416	0.546
ROA (%)	29,485	7.941	10.02	3.120	7.920	13.54
MB	29,485	1.924	1.598	0.970	1.450	2.260
Age (Months)	29,485	334.4	167.2	207	313	444
lnAge	29,485	5.661	0.602	5.333	5.746	6.096
Crossholding	29,485	0.189	0.391	0	0	0
Moderators						
Analyst	29,485	6.394	22.91	0	0	4
Turnover (%)	29,485	165.0	248.4	28.83	80.51	205.6
Groupholding (%)	29,485	20.91	19.69	3.560	16.11	33.84
Instrumental Variables						
Highedu	29,485	0.468	0.255	0.286	0.455	0.667
NScore_ind	29,485	0.538	0.128	0.463	0.550	0.600
Others						
ShortIB	12,418	0.008	0.012	4.01e-04	0.003	0.011
Inboard	12,418	0.338	0.111	0.250	0.333	0.429
Sinstinv	12,418	0.306	0.205	0.140	0.274	0.452
Smainsh	12,418	0.237	0.133	0.141	0.212	0.307

Notes: This table reports the summary statistics of the key variables used in this study. The dependent variable of ***SYNCH*** stands for the synchronicity of stock returns and, according to Morck et al. (2000) and Jin and Myers (2006), is calculated as $SYNCH_{i,t} = ln\left(\frac{R^2_{i,t}}{(1-R^2_{i,t})}\right)$, where $R^2_{i,t}$ is the gauged from the Carhart (1997) four-factor model. The main variables of board centrality include ***DEG***, denoting the degree of centrality, which is defined as a total number of direct connections to the other firms through interlocking directorates ($DEG_i \equiv \sum_{j \neq i} \delta(i,j)$). ***CLOSE*** denotes closeness centrality, which measures how close it is to all other firms through the reachable shortest paths and is calculated as the inverse value of the average distance of these shortest path ($CLOSE_i \equiv \frac{n-1}{\sum_{j \neq i} l(i,j)}$). ***EIGEN*** denotes the eigenvector centrality, which measures the quality or the power of the firm within a network ($\lambda \times CENTRALITY \equiv \sum_j g_{i,j} \times CENTRALITY_j$, and $\lambda \times EIGENVECTOR = G \times EIGENVECTOR$, where λ is the proportionality factor and $g_{i,j} = 1$ if firm *i* and firm *j* are interlocked, and *G* is the matrix of *EIGENVECTOR*). ***BETW*** denotes the betweenness centrality, which measures how often a firm can sit between two other firms through director interlocks ($BTWN_i \equiv \sum_{j \neq i : i \notin (k,j)} \frac{P_i(k,j)/P(k,j)}{(n-1)(n-2)/2}$, where $P_i(k,j)$ denotes the number of shortest paths between firm *k* and firm *j* that firm *i* lies on and $P(k,j)$ denotes the total number of shortest paths between firm *k* and firm *j*, then for a firm *i* in the network). $\boldsymbol{NScore} \equiv \frac{1}{4}(r_{DEG} + r_{CLOSE} + r_{BTWN} + r_{EIGN})$, where r_{DEG}, r_{CLOSE}, r_{BTWN}, and r_{EIGN} denote rank score of firms being classified into deciles based on degree centrality, closeness

centrality, betweenness centrality, and eigenvector centrality, respectively. All deciles are divided by 10, making *NScore* range between 0.1 and 1. Alternative centrality measures, including ***DEG_cross, CLOSE_cross, EIGEN_cross, BETW_cross,*** and ***NScore_cross***, consider only cross-sector external directorships. Similarly, ***DEG_nonm, CLOSE_nonm, EIGEN_nonm, BETW_nonm,*** and ***NScore_nonm*** account only for non-manager external directorships when calculating centrality.

Control variables include ***lnAge*** which is the natural logarithm of firm's age (recorded in months) since inception. *Leverage* denotes financial leverage and is defined as total debt divided by total assets. ***Size*** is the natural logarithm of the market value of equity (*MV*). ***MB*** denotes the natural logarithm of the ratio of market value of equity over total equity. ***ROA*** is earnings before interest and taxes divided by total assets. An indicator variable, ***Crossholding***, equals to one when a firm possesses cross shareholding, and zero, otherwise.

The moderators include ***Analyst*** which denotes the number of following analysts. ***Turnover*** denotes the total number of trading shares divided by the average number of shares outstanding. ***Groupholding*** denotes the total shareholding held by listed firms, unlisted firms and funds that are ultimately controlled by the controlling group.

Instrument variables include ***Highedu*** which denotes the proportion of directors with a master's degree or higher. ***Nscore_ind*** denotes the industry median of Nscore.

Other variables include ***ShortIB***, which represents the current shares sold short as a proportion of total outstanding shares. ***Inboard*** denotes the proportion of independent directors on the board. ***Sinstinv*** represents the ratio of total institutional shareholding to total outstanding shares. ***Smainsh*** refers to the total shareholding of the top 10 shareholders.

In Table 3, we report the Pearson's correlation coefficients among variables. The result shows that stock return synchronicity is positively correlated with different centrality measures (DEG, CLOSE, EIGEN, BETW, and NScore) at 1% significance level. This supports Hypothesis 1, which implies that firms with high boardroom centrality are associated with higher levels of stock return synchronicity. Moreover, we find that stock return synchronicity positively correlates with firm size, age, cross-shareholding, analyst coverage, and turnover while negatively correlated with leverage, market-to-book equity, and group holding.

Table 3 Pearson's Correlation Coefficient

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*
(1) SYNCH	1.00													
(2) DEG	0.17*** (0.00)	1.00												
(3) CLOSE	0.07*** (0.00)	0.62*** (0.00)	1.00											
(4) EIGEN	0.14*** (0.00)	0.71*** (0.00)	0.33*** (0.00)	1.00										
(5) BETW	0.11*** (0.00)	0.81*** (0.00)	0.43*** (0.00)	0.54*** (0.00)	1.00									
(6) NScore	0.18*** (0.00)	0.87*** (0.00)	0.68*** (0.00)	0.55*** (0.00)	0.72*** (0.00)	1.00								
(7) Size	0.47*** (0.00)	0.33*** (0.00)	0.20*** (0.00)	0.27*** (0.00)	0.28*** (0.00)	0.33*** (0.00)	1.00							
(8) Leverage	-0.04*** (0.00)	-0.02*** (0.00)	-0.04*** (0.00)	0.01 (0.13)	-0.02*** (0.00)	-0.03*** (0.00)	0.03*** (0.00)	1.00						
(9) ROA	0.30*** (0.00)	0.06*** (0.00)	0.06*** (0.00)	0.06*** (0.00)	0.03*** (0.00)	0.07*** (0.00)	0.40*** (0.00)	-0.12*** (0.00)	1.00					
(10) MB	-0.07*** (0.00)	0.00 (0.79)	-0.00 (0.82)	-0.03*** (0.00)	0.02*** (0.00)	0.05*** (0.00)	0.25*** (0.00)	-0.02*** (0.00)	0.10*** (0.00)	1.00				
(11) lnAge	0.13*** (0.00)	-0.08*** (0.00)	-0.08*** (0.00)	-0.01 (0.25)	-0.04*** (0.00)	-0.06*** (0.00)	0.14*** (0.00)	0.13*** (0.00)	-0.00 (0.83)	-0.21*** (0.00)	1.00			
(12) Crossholding	0.15*** (0.00)	0.20*** (0.00)	0.10*** (0.00)	0.19*** (0.00)	0.12*** (0.00)	0.17*** (0.00)	0.22*** (0.00)	0.04*** (0.00)	-0.02*** (0.00)	-0.13*** (0.00)	0.19*** (0.00)	1.00		
(13) Analyst	0.14*** (0.00)	0.10*** (0.00)	0.12*** (0.00)	0.05*** (0.00)	0.13*** (0.00)	0.12*** (0.00)	0.38*** (0.00)	0.03*** (0.00)	0.19*** (0.00)	0.14*** (0.00)	0.04*** (0.00)	-0.01 (0.19)	1.00	
(14) Turnover	0.35*** (0.00)	0.04*** (0.00)	0.03*** (0.00)	0.02*** (0.00)	0.04*** (0.00)	0.08*** (0.00)	0.20*** (0.00)	-0.04*** (0.00)	0.19*** (0.00)	0.17*** (0.00)	-0.02*** (0.00)	-0.03*** (0.00)	0.12*** (0.00)	1.00
(15) Groupholding	-0.12*** (0.00)	0.07*** (0.00)	0.04*** (0.00)	0.07*** (0.00)	0.03*** (0.00)	0.07*** (0.00)	0.06*** (0.00)	0.06*** (0.00)	0.02*** (0.00)	0.03*** (0.00)	-0.03*** (0.00)	0.09*** (0.00)	-0.03*** (0.00)	-0.19*** (0.00)

4. Empirical Results

Table 4 reports the panel regression of stock return synchronicity on alternative centrality measures and other control variables. We control yearly and firm fixed effects in the models, aiming at controlling for omitted variable bias due to unobserved heterogeneity. [9] We note that because alternative centrality measures disperse significantly in scale, we normalize them by assigning rank scores in the range between 0.1 and 1. Specifically, firms in the first decile of alternative centrality measures are assigned the value 0.1, 0.2 for the second decile, and so on. The higher rank score implies a higher centrality position of a firm situated in the networks of interlocking directorship. The panel regression results show that all centrality measures positively correlate with stock return synchronicity. This evidence renders support to Hypothesis 1. We postulate that the positive centrality-synchronicity relation could be jointly dictated by the following conditions: (1) board interlocking speeds the information transformation so that most firm-specific information has been incorporated into current stock prices (e.g., Dasgupta et al., 2010); (2) board interlocking facilitates the spread of business practices and strategic moves so as to result in comovement in fundamentals (Barberis et al., 2005), (3) board interlocking lowers the information searching costs for investors who in turn focus on a common subset of interlocking firms (Veldkamp, 2006).

The control variables are included in reference to prior studies (e.g., Crawford, Roulstone & So, 2012; Dasgupta et al., 2010; Dong et al., 2016; Hutton et al., 2009; Kim & Shi, 2012; Piotroski & Roulstone, 2004). We find that the firm's size (Size), ROA, age (lnAge), and cross-holding dummy are positively correlated with stock return synchronicity, while the market-to-book ratio (MB) is negatively correlated with stock return synchronicity. The positive impact of age and size is mainly because the market learns more about the time-invariant characteristics of older firms so that the stock prices tend to comove (e.g., Piotroski & Roulstone, 2004; Gul et al., 2011). The positive impact of ROA is probably because firms with higher profitability are likely to have lower stock price informativeness (Ben-Nasr & Cosset, 2014; Gul et al., 2011). The positive impact of the cross-holding dummy is consistent with the findings of Wen et al. (2021), who indicated that cross-shareholding benefits the information environment so that pricing errors or noise trading are mitigated. An improvement in the information environment leads to higher stock return synchronicity. Finally, the negative impact of the market-to-book ratio is mainly because that high market-to-book ratio could be considered a high risk to deter investors so as to deteriorate the information environment and, therefore, lower the level of stock return synchronicity. Alternatively, firms with a high market-to-book ratio tend to be associated with higher growth opportunities and commove less with market trends.

[9] Alternatively, we control for industry and time fixed effects, recognizing that synchronicity may be influenced by extreme events—such as COVID and the financial crisis, which are relevant to their sample—that affect either the entire economy or specific sectors. The (unreported) results from controlling for sector-time fixed effects, as well as the findings excluding the financial crisis and the COVID period, remain consistent.

Table 4 Fixed Effect Regression of Stock Synchronicity on Board Centrality from All Board Members

Dependent Variable: Stock Synchronicity	(1)	(2)	(3)	(4)	(5)
	Centrality= DEG	Centrality= BETW	Centrality= CLOSE	Centrality= EIGEN	Centrality= NScore
Centrality	9.832***	8.375***	8.918***	7.587**	12.14***
	(2.93)	(2.94)	(2.78)	(2.48)	(3.22)
Size	40.75***	40.87***	40.79***	40.93***	40.74***
	(22.95)	(23.03)	(22.99)	(23.05)	(22.97)
Leverage	-8.493	-8.434	-8.344	-8.232	-8.372
	(-1.35)	(-1.34)	(-1.33)	(-1.31)	(-1.33)
ROA	0.771***	0.769***	0.769***	0.766***	0.772***
	(7.76)	(7.75)	(7.74)	(7.70)	(7.77)
MB	-10.86***	-10.89***	-10.86***	-10.90***	-10.85***
	(-15.36)	(-15.44)	(-15.38)	(-15.47)	(-15.37)
lnAge	15.01***	14.90***	15.08***	15.17***	15.24***
	(3.18)	(3.16)	(3.19)	(3.22)	(3.23)
Crossholding	5.670**	5.645**	5.718**	5.693**	5.643**
	(2.36)	(2.35)	(2.38)	(2.37)	(2.35)
_cons	-517.5***	-517.8***	-518.1***	-517.8***	-520.1***
	(-18.17)	(-18.17)	(-18.17)	(-18.18)	(-18.23)
Year Effect	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y
N	29485	29485	29485	29485	29485
R^2	0.436	0.436	0.436	0.435	0.436

In Table 5, we explore the moderator effect of analyst coverage on the positive centrality-synchronicity relation. We find that analysts' coverage (lnAnalyst) is significantly positively correlated with stock return synchronicity. This is consistent with prior findings that analyst coverage improves stock price informativeness, as analysts produce more firm-specific information to increase the investment value of their research (Liu, 2011). Specifically, Crawford et al. (2012) propose that the first analyst to initiate coverage provides the low-cost market and industry information, while the following analysts attempt to produce firm-specific information to differentiate their services from the existing one.

We further explore the possible moderator effect of analyst coverage on the relation between centrality and stock return synchronicity. The result shows that the interaction term between centrality and analyst coverage (Centrality × lnAnalyst) is significantly negative. Since both centrality and analyst coverage are related to informativeness, the two might be conceptually redundant, and the negative moderator effect of analyst coverage implies the substitution effect. That implies the effect of board centrality in enhancing the speed of information transmission is less critical, leading to high stock return synchronicity when underlying firms have been extensively followed by analysts and vice versa. This evidence supports Hypothesis 2.

Table 5 The Moderator Effect of Analyst Coverage

Dependent Variable: Stock Synchronicity					
	(1)	(2)	(3)	(4)	(5)
	Centrality= DEG	Centrality= BTWN	Centrality= CLOSE	Centrality= EIGEN	Centrality= NScore
Centrality	13.52***	11.69***	14.29***	17.41***	19.34***
	(3.34)	(3.35)	(3.72)	(4.66)	(4.26)
Centrality lnAnalyst*	-4.028**	-3.689**	-5.998***	-11.34***	-7.885***
	(-2.49)	(-2.40)	(-3.74)	(-6.41)	(-4.22)
lnAnalyst	4.316***	4.080***	5.509***	9.467***	6.769***
	(3.63)	(3.58)	(4.66)	(6.95)	(5.06)
Size	39.73***	39.88***	39.75***	39.79***	39.67***
	(21.67)	(21.75)	(21.72)	(21.76)	(21.68)
Leverage	-9.305	-9.292	-9.216	-9.067	-9.274
	(-1.48)	(-1.48)	(-1.47)	(-1.45)	(-1.48)
ROA	0.766***	0.765***	0.761***	0.736***	0.763***
	(7.69)	(7.70)	(7.64)	(7.39)	(7.66)
MB	-10.76***	-10.79***	-10.74***	-10.88***	-10.75***
	(-15.15)	(-15.22)	(-15.17)	(-15.43)	(-15.16)
lnAge	14.93***	14.76***	15.17***	15.47***	15.33***
	(3.16)	(3.13)	(3.22)	(3.29)	(3.25)
Crossholding	5.672**	5.680**	5.700**	5.765**	5.620**
	(2.35)	(2.36)	(2.37)	(2.41)	(2.34)
_cons	-513.2***	-513.2***	-515.3***	-518.9***	-518.4***
	(-17.91)	(-17.88)	(-18.00)	(-18.17)	(-18.08)
Year Effect	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y
N	29485	29485	29485	29485	29485
R^2	0.436	0.436	0.436	0.437	0.436

In Table 6, we explore the moderator effect of stock turnover. The result shows that stock turnover is positively correlated with stock return synchronicity. This is consistent with Brockman and Yan (2009), indicating that active trading helps to incorporate more industry-specific information into stock prices. Moreover, we find that the interaction between board centrality and stock turnover is significantly negative. The negative moderator effect of stock turnover is also consistent with the substitution effect. That is, the effect of board centrality on the speed of information transmission is less critical when the underlying stock is actively traded and vice versa. The result supports Hypothesis 3.

Table 6 The Moderator Effect of Turnover Rate

Dependent Variable: Stock Synchronicity					
	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Centrality= DEG	***Centrality= BTWN***	***Centrality= CLOSE***	***Centrality= EIGEN***	***Centrality= NScore***
Centrality	34.64***	29.26***	40.62***	40.58***	48.37***
	(4.40)	(4.05)	(5.24)	(5.31)	(5.43)
Centrality lnTurnover*	-5.145***	-4.496***	-6.874***	-7.190***	-7.765***
	(-3.29)	(-3.05)	(-4.42)	(-4.81)	(-4.40)
lnTurnover	24.37***	24.04***	25.24***	25.47***	25.75***
	(23.13)	(23.83)	(24.14)	(24.82)	(22.61)
Size	28.11***	28.32***	28.19***	28.41***	28.15***
	(17.56)	(17.68)	(17.65)	(17.87)	(17.63)
Leverage	-6.514	-6.301	-6.418	-6.560	-6.493
	(-1.13)	(-1.09)	(-1.11)	(-1.14)	(-1.13)
ROA	0.625***	0.619***	0.621***	0.619***	0.626***
	(6.69)	(6.63)	(6.65)	(6.63)	(6.69)
MB	-10.49***	-10.54***	-10.45***	-10.53***	-10.44***
	(-15.55)	(-15.66)	(-15.50)	(-15.75)	(-15.49)
lnAge	-2.495	-2.659	-2.384	-2.225	-2.195
	(-0.61)	(-0.65)	(-0.58)	(-0.54)	(-0.53)
Crossholding	5.597***	5.584***	5.677***	5.595***	5.587***
	(2.65)	(2.64)	(2.69)	(2.66)	(2.65)
_cons	-438.0***	-436.8***	-442.5***	-444.2***	-447.5***
	(-17.40)	(-17.29)	(-17.59)	(-17.70)	(-17.67)
Year Effect	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y
N	29485	29485	29485	29485	29485
R^2	0.480	0.480	0.480	0.480	0.480

In Table 7, we explore the moderator effect of group holding. This moderator is inspired by the complexity of ownership arrangement by controlling owners. Specifically, group holding includes the shareholding by unlisted firms and funds under the control of controlling owners. These unlisted firms or funds are opaque and hard to be specifically traced. The complexity of the shareholding arrangement facilitates ownership concentration by controlling owners. Fan and Wong (2002) indicate that concentrated ownership tends to be associated with pyramidal and cross-holding structures, which create agency conflicts between controlling owners and outside investors. The informativeness of reported earnings is adversely affected by self-interested purposes of controlling owners on the one hand and the prevention of leaking proprietary information on the other. Therefore, group holding is deemed as a negative indicator of informativeness. The result in Table 7 indicates that group holding negatively correlates with stock return synchronicity, indicating that group holding reduces informativeness and, therefore, a lower level of stock comovement. By contrast, the interaction between centrality and group holding is positive, implying that board centrality is more critical in speeding information transmission and, therefore, an increase in stock return synchronicity when firms have a high group holding level. Hypothesis 4 is supported herein.

Table 7 The Moderator Effect of Group Holding

	(1) Centrality= Degree	*(2) Centrality= Between*	*(3) Centrality= Close*	*(4) Centrality= Eigen*	*(5) Centrality= Nscore*
Centrality	4.792	4.839	3.306	3.195	5.512
	(1.05)	(1.23)	(0.76)	(0.83)	(1.09)
Centrality*	0.262	0.164	0.286*	0.246*	0.341*
Groupholding	(1.56)	(1.18)	(1.82)	(1.78)	(1.85)
Groupholding	-0.374***	-0.317**	-0.385***	-0.372***	-0.416***
	(-2.79)	(-2.55)	(-3.08)	(-3.11)	(-3.00)
Size	40.96***	41.08***	41.03***	41.13***	40.99***
	(23.10)	(23.21)	(23.14)	(23.20)	(23.13)
Leverage	-7.734	-7.642	-7.527	-7.436	-7.604
	(-1.23)	(-1.21)	(-1.20)	(-1.18)	(-1.21)
ROA	0.792***	0.787***	0.790***	0.787***	0.792***
	(7.91)	(7.87)	(7.89)	(7.85)	(7.91)
MB	-10.89***	-10.91***	-10.89***	-10.90***	-10.88***
	(-15.44)	(-15.52)	(-15.45)	(-15.52)	(-15.45)
lnAge	13.83***	13.70***	13.89***	13.95***	14.02***
	(2.92)	(2.89)	(2.93)	(2.95)	(2.96)
Crossholding	5.871**	5.828**	5.923**	5.947**	5.877**
	(2.45)	(2.44)	(2.48)	(2.49)	(2.46)
_cons	-506.9***	-507.8***	-507.3***	-507.3***	-508.8***
	(-17.67)	(-17.65)	(-17.70)	(-17.68)	(-17.72)
Year Effect	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y
N	29485	29485	29485	29485	29485
R^2	0.436	0.436	0.436	0.436	0.436

5. Robustness Check

Our argument connecting board centrality and stock return synchronicity hinges on the transmission of information through board interlocking, which allows most firm-specific information to be incorporated into stock returns. In this section, we introduce new variables for robustness checks. The descriptive statistics for these variables are provided in Table 2.

The very first intriguing issue is the endogeneity problem associated with centrality and stock return synchronicity. Someone might question the possible reversal causality in the sense that stocks with a high degree of synchronicity are well-noted firms, and these firms happen to attract talented people serving directorship. Another possibility is that some unknown firm characteristics or market conditions simultaneously affect centrality and synchronicity. To address this issue, we conduct 2SLS regressions with alternative instruments.

The first instrument of interest is the proportion of directors having a master's degree or above (Highedu). This postulation is based on the premise that directors with higher educational backgrounds tend to be appointed as directors, which results in high board centrality. However, the directors' educational background composition is

unrelated to stock return synchronicity. In Table 8, we conduct 2SLS with the instrument of the proportion of directors having master's degrees or above. The result shows that the instrument of proportion of higher education is positively correlated with board centrality. The fitted centrality measures are included in the second-stage regressions. The result shows that the fitted centrality positively correlates with stock return synchronicity.

In Table 9, we alternatively use the lagged industry median centrality (NScore_ind) as the instrument and conduct two-stage regression. The use of alternative instruments in 2SLS yields qualitatively similar results.

Table 8 Two Stage Least Square Regression Using the Instrument of the Proportion of Board Members Receiving High Education (Highedu)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
	Centrality= DEG	***Centrality= DEG***	***Centrality= BTWN***	***Centrality= BTWN***	***Centrality= CLOSE***	***Centrality= CLOSE***	***Centrality= EIGEN***	***Centrality= EIGEN***	***Centrality= NScore***	***Centrality= NScore***
Highedu.	0.254**		0.247***		0.240***		0.179***		0.230***	
	(19.12)		(18.02)		(18.31)		(14.24)		(19.60)	
Centralityhat		69.41***		71.32***		73.62***		98.65***		76.70***
		(4.41)		(4.42)		(4.43)		(4.34)		(4.43)
Size	0.046***	39.95***	0.037***	40.50***	0.047***	39.68***	0.039***	39.29***	0.042***	39.90***
	(15.48)	(28.91)	(12.71)	(30.81)	(16.18)	(28.02)	(13.48)	(26.37)	(16.35)	(28.83)
Leverage	0.006	-18.11***	0.002	-17.87***	-0.009	-17.15***	-0.010	-16.67***	-0.003	-17.50***
	(0.40)	(-3.33)	(0.13)	(-3.30)	(-0.59)	(-3.18)	(-0.70)	(-3.02)	(-0.21)	(-3.24)
ROA	-0.001***	0.911***	-0.001***	0.909***	-0.001***	0.912***	-0.001***	0.914***	-0.001***	0.911***
	(-6.04)	(9.76)	(-5.39)	(9.83)	(-5.78)	(9.77)	(-4.63)	(9.69)	(-6.22)	(9.81)
MB	-0.011***	-10.67***	-0.009***	-10.80***	-0.012***	-10.53***	-0.011***	-10.39***	-0.011***	-10.61***
	(-6.79)	(-16.61)	(-5.49)	(-17.12)	(-7.58)	(-16.20)	(-7.16)	(-15.69)	(-7.55)	(-16.55)
lnAge	-0.024***	18.54***	-0.017***	18.08***	-0.034***	19.31***	-0.029***	19.67***	-0.026***	18.84***
	(-3.66)	(7.54)	(-2.56)	(7.45)	(-5.10)	(7.65)	(-4.46)	(7.57)	(-4.32)	(7.59)
Crossholding	0.026***	3.096	0.027***	3.012	0.021***	3.365	0.025***	2.496	0.025***	3.032
	(3.75)	(1.33)	(3.68)	(1.30)	(3.01)	(1.45)	(3.42)	(1.04)	(4.02)	(1.31)
_cons	0.259***	-573.7***	0.386***	-583.3***	0.347***	-581.4***	0.276***	-582.9***	0.317***	-580.1***
	(6.57)	(-36.59)	(9.69)	(-34.71)	(8.81)	(-35.12)	(7.36)	(-34.32)	(8.93)	(-35.42)
Year Effect	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	29485	29485	29485	29485	29485	29485	29485	29485	29485	29485
R^2	0.233	0.429	0.198	0.429	0.246	0.427	0.311	0.411	0.262	0.428

Table 9 Two Stage Least Square Regression Using the Instrument of the Sector's Median of Centrality (NScore_ind)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
	Centrality= DEG	***Centrality= DEG***	***Centrality= BTWN***	***Centrality= BTWN***	***Centrality= CLOSE***	***Centrality= CLOSE***	***Centrality= EIGEN***	***Centrality= EIGEN***	***Centrality= NScore***	***Centrality= NScore***
NScore_ind	0.554***		0.471***		0.588***		0.431***		0.511***	
	(25.71)		(21.73)		(27.16)		(19.18)		(26.49)	
Centralityhat		29.10**		34.14**		27.49**		37.17**		31.58**
		(2.44)		(2.44)		(2.46)		(2.42)		(2.45)
Size	0.046***	41.98***	0.037***	42.03***	0.046***	42.05***	0.038***	41.88***	0.042***	42.00***
	(15.08)	(32.65)	(12.48)	(32.88)	(15.70)	(33.12)	(13.13)	(31.96)	(15.98)	(32.76)
Leverage	0.008	-17.81***	0.003	-17.59***	-0.006	-17.50***	-0.009	-17.07***	-0.001	-17.59***
	(0.53)	(-3.31)	(0.17)	(-3.27)	(-0.39)	(-3.26)	(-0.59)	(-3.15)	(-0.07)	(-3.27)
ROA	-0.002***	0.841***	-0.001***	0.846***	-0.001***	0.836***	-0.001***	0.835***	-0.001***	0.840***
	(-6.43)	(9.28)	(-5.75)	(9.30)	(-6.15)	(9.30)	(-4.90)	(9.25)	(-6.63)	(9.31)
MB	-0.011***	-11.16***	-0.009***	-11.16***	-0.012***	-11.15***	-0.010***	-11.08***	-0.011***	-11.14***
	(-6.68)	(-18.38)	(-5.38)	(-18.37)	(-7.40)	(-18.43)	(-6.87)	(-18.12)	(-7.41)	(-18.37)
lnAge	-0.027***	16.68***	-0.022***	16.66***	-0.034***	16.82***	-0.030***	17.00***	-0.028***	16.78***
	(-4.05)	(7.11)	(-3.25)	(7.08)	(-5.13)	(7.15)	(-4.54)	(7.10)	(-4.67)	(7.13)
Crossholding	0.025***	4.249*	0.026***	4.113*	0.020***	4.428**	0.024***	4.140*	0.024***	4.230*
	(3.60)	(1.88)	(3.51)	(1.82)	(2.89)	(1.97)	(3.33)	(1.82)	(3.90)	(1.88)
_cons	0.063	-556.5***	0.242***	-562.9***	0.120**	-558.0***	0.117**	-558.9***	0.134***	-558.9***
	(1.53)	(-38.23)	(5.81)	(-35.93)	(2.93)	(-37.87)	(2.91)	(-37.25)	(3.62)	(-37.53)
Year Effect	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	29485	29485	29485	29485	29485	29485	29485	29485	29485	29485
R^2	0.196	0.439	0.162	0.439	0.210	0.440	0.294	0.436	0.224	0.440

We highlight the critical role of information transformation in linking board centrality to stock return synchronicity. One might argue that the comovement of stock returns is more attributable to operational similarities within the same sector than to information transmission through interlocking directors. Specifically, firms within the same industry or sector face similar operational risks, which could explain the comovement of stock returns within that sector. In Panel A of Table 10, we redefine and recalculate the centrality measures by considering only cross-sector board interlockings, excluding interlocks within the same sector (industry) from the calculations. The results remain qualitatively consistent. In other words, the relationship between board centrality and stock return synchronicity is not significantly influenced by the same-sector effect. Information transmission among interlocking firms continues to provide the most robust explanation for the positive relationship between board centrality and stock return synchronicity.

In Panel B of Table 10, we redefine the centrality measures by excluding counts of incumbent managers serving on the boards of their owned companies. Specifically, only non-managerial external directorships are considered. This adjustment addresses concerns that incumbent managers holding directorships at owned companies may not accurately reflect board effects. The results of Panel B remain unchanged.[10]

[10] Additionally, to control for the confounding effect of ownership, we use the wedge between control rights and cash flow rights (CR/CFR) as an instrument and conduct a 2SLS analysis. This instrument is chosen under the assumption that controlling owners with a larger wedge are more likely to pursue aggressive external connections, which are more reliant on firms as a whole rather than on individual board members. The (unreported) results of the 2SLS, instrumented by the control/cash flow rights wedge, remain qualitatively consistent.

Table 10 Fixed Effect Regression- Alternative Definitions of Centrality Measures

Panel A: Only cross-sector external directorships are counted

Dependent Variable: Stock Synchronicity

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Centrality= DEG_cross	***Centrality= BTWN_cross***	***Centrality= CLOSE_cross***	***Centrality= EIGEN_cross***	***Centrality= NScore_cross***
Centrality _cross	9.583*** (2.95)	6.263** (2.27)	8.975*** (2.82)	7.182** (2.34)	11.22*** (3.00)
Size	40.79*** (22.93)	40.96*** (23.06)	40.81*** (23.00)	40.98*** (23.08)	40.81*** (22.99)
Leverage	-8.370 (-1.33)	-8.336 (-1.32)	-8.343 (-1.33)	-8.232 (-1.31)	-8.298 (-1.32)
ROA	0.770*** (7.74)	0.766*** (7.71)	0.769*** (7.72)	0.764*** (7.68)	0.770*** (7.73)
MB	-10.86*** (-15.33)	-10.91*** (-15.46)	-10.86*** (-15.38)	-10.91*** (-15.48)	-10.86*** (-15.37)
lnAge	15.09*** (3.20)	14.82*** (3.14)	15.24*** (3.23)	15.26*** (3.24)	15.32*** (3.25)
Crossholding	5.651** (2.35)	5.743** (2.39)	5.706** (2.38)	5.677** (2.37)	5.664** (2.36)
_cons	-518.4*** (-18.24)	-516.7*** (-18.15)	-519.3*** (-18.23)	-517.9*** (-18.21)	-520.5*** (-18.27)
Year Effect	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y
N	29485	29485	29485	29485	29485
R^2	0.436	0.435	0.436	0.435	0.436

Table 10 Fixed Effect Regression- Alternative Definitions of Centrality Measures Continued

Panel B: Only non-manager external directorships are counted

Dependent Variable: Stock Synchronicity

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Centrality= DEG_nonm	***Centrality= BTWN_nonm***	***Centrality= CLOSE_nonm***	***Centrality= EIGEN_nonm***	***Centrality= NScore_nonm***
Centrality	9.435***	6.785**	9.245***	9.435***	12.14***
	(2.95)	(2.50)	(2.91)	(3.34)	(3.22)
Size	40.76***	40.93***	40.75***	40.95***	40.74***
	(22.97)	(23.04)	(23.03)	(23.06)	(22.97)
Leverage	-8.524	-8.449	-8.405	-8.323	-8.372
	(-1.36)	(-1.34)	(-1.34)	(-1.32)	(-1.33)
ROA	0.770***	0.765***	0.771***	0.768***	0.772***
	(7.75)	(7.71)	(7.75)	(7.72)	(7.77)
MB	-10.86***	-10.90***	-10.85***	-10.89***	-10.85***
	(-15.36)	(-15.43)	(-15.38)	(-15.46)	(-15.37)
lnAge	15.06***	14.87***	15.21***	15.28***	15.24***
	(3.19)	(3.15)	(3.22)	(3.24)	(3.23)
Crossholding	5.714**	5.732**	5.758**	5.639**	5.643**
	(2.38)	(2.39)	(2.40)	(2.35)	(2.35)
_cons	-517.9***	-517.0***	-518.7***	-519.6***	-520.1***
	(-18.18)	(-18.14)	(-18.15)	(-18.25)	(-18.23)
Year Effect	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y
N	29485	29485	29485	29485	29485
R^2	0.436	0.435	0.436	0.436	0.436

6. A Further Discussion

Our main argument lies on the premise that the quick information transmission among involved firms leads to the condition that most firm-specific information has been incorporated into stock prices, leaving little space for stock returns to be further affected by any arrival of new firm-specific information. When the connections are a conduit of information exchange, the potential of informed trading increases, facilitating the dissemination of information into stock prices (Akbas et al., 2016). The more rapidly the information is incorporated into stock prices, the higher the level of price informativeness and the stock return synchronicity (Dasgupta et al., 2010).

The aforementioned argument is in tandem with the network view illustrated by Cheng et al. (2019). However, they alternatively propose the governance view, suggesting that the reputation capital of a board's directors, serving as a strong governance mechanism, mitigates nonpublic information leakage. Stock returns could comove under this condition since most stock prices reflect market-wide shocks. In this discussion, we further incorporate several variables of information leakage and governance into the analysis to see which would prevail in explaining the positive centrality-synchronicity.

Table 11 presents the main results from the fixed effect regressions of stock synchronicity on board centrality and variables surrogating for information leakage and governance. Since the reliable data on short selling (ShortIB in Panel B) is only available from 2017 through 2024, we reconduct the analysis using this sub-period sample. Panel A excerpts the main result and confirms a positive centrality-synchronicity relation. In Panel B, we additionally include short selling (ShortIB), being defined as the share sold short divided by total outstanding shares. We find that short selling positively correlates with the stock return synchronicity at the 1% significance level. This further rends supporting evidence to the network view of Cheng et al. (2019).

By contrast, in Panel C through E, we introduce board independence (Inboard), institutional holding (Sinstinv), and large shareholding (Smainsh) into analysis and find institutional holding and large shareholding significantly affect stock return synchronicity. These variables are chosen to proxy for governance. For example, a board comprised of more independent directors is supposed to be more effective in directors' monitoring and strategic roles. Moreover, Chung and Zhang (2011) indicate that institutional holding positively correlates with the quality of governance structure. The proportion of institutions that hold a firm's shares also increases with its governance quality. Furthermore, ownership concentration, using the proxy of the holding of the top 10 shareholders, is supposed to be positively correlated with governance quality and firm value (e.g., Morck, Shleifer & Vishny, 1988). We note that the two governance variables, institutional holding and large shareholding, are negatively correlated with stock return synchronicity. This suggests that firms with better governance are less likely to experience private leakage of corporate information, which in turn leads to lower stock return synchronicity. This further supports the governance view.

Even though governance quality affects the information environment and reduces information leakage, informed traders are capitalizing on advanced knowledge of this information. As indicated by Akbas et al. (2016), board connections affect the

external corporate information environment, increase the potential for informed trading, and facilitate the dissemination of information into stock prices.[11] This section concludes that the positive centrality-synchronicity relation remains significant after the control of network view and governance view.

[11] They validate that sophisticated traders can obtain privileged information from directors and trade profitably on that information before it becomes available to the broader market. More profitable informed trading occurs in firms with more connected boards.

Table 11 Excerption of the Fixed Effect Regression of Stock Synchronicity on Board Centrality

Dependent Variable: Stock Synchronicity

	(1) Centrality= DEG	*(2) Centrality= BTWN*	*(3) Centrality= CLOSE*	*(4) Centrality= EIGEN*	*(5) Centrality= NScore*
Panel A: Subsample, 2017–2024					
Centrality	11.60***	11.53***	8.413**	2.861	12.96***
	(2.87)	(3.07)	(2.21)	(0.61)	(2.70)
Control Var.	Y	Y	Y	Y	Y
Year Effect	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y
N	12418	12418	12418	12418	12418
R^2	0.506	0.506	0.505	0.505	0.506
Panel B: Inclusion Short Sale (ShortIB)					
Centrality	11.78***	11.64***	8.418**	2.741	13.04***
	(2.92)	(3.11)	(2.21)	(0.58)	(2.73)
ShortIB	3.964***	3.957***	3.941***	3.938***	3.949***
	(5.85)	(5.84)	(5.82)	(5.82)	(5.83)
Control Var.	Y	Y	Y	Y	Y
Year Effect	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y
N	12418	12418	12418	12418	12418
R^2	0.507	0.507	0.507	0.506	0.507
Panel C: Inclusion Board Independence (Inboard)					
Centrality	11.49***	11.45***	8.268**	2.509	12.75***
	(2.84)	(3.04)	(2.17)	(0.53)	(2.66)
Inboard	12.64	12.73	12.64	12.97	12.32
	(1.27)	(1.28)	(1.27)	(1.30)	(1.24)
Control Var.	Y	Y	Y	Y	Y
Year Effect	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y
N	12418	12418	12418	12418	12418
R^2	0.506	0.506	0.505	0.505	0.506

Table 11 Excerption of the Fixed Effect Regression of Stock Synchronicity on Board Centrality Continued

Panel D: Inclusion Institutional Shareholding (Sinstinv)					
Centrality	12.34***	12.22***	9.123**	3.763	14.02***
	(3.06)	(3.26)	(2.41)	(0.80)	(2.93)
Sinstinv	-47.81***	-47.86***	-47.43***	-46.74***	-47.96***
	(-3.86)	(-3.86)	(-3.82)	(-3.75)	(-3.87)
Control Var.	Y	Y	Y	Y	Y
Year Effect	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y
N	12418	12418	12418	12418	12418
R^2	0.507	0.507	0.506	0.506	0.507
Panel E: Inclusion Total Shareholding by Top 10 Shareholders (Smainsh)					
Centrality	11.54***	11.52***	8.413**	2.776	12.91***
	(2.87)	(3.09)	(2.22)	(0.59)	(2.71)
Smainsh	-56.65***	-56.74***	-56.75***	-56.73***	-56.69***
	(-4.53)	(-4.54)	(-4.53)	(-4.53)	(-4.53)
Control Var.	Y	Y	Y	Y	Y
Year Effect	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y
N	12418	12418	12418	12418	12418
R^2	0.507	0.507	0.507	0.506	0.507

7. Concluding Remarks

In this study we uncover a positive centrality-synchronicity relation using the data of listed firms in Taiwan. We portray the role of information transmission associated with board centrality and illustrate that board centrality speeds the information transmission among interlocking firms so that most firm-specific information has mainly been incorporated into stock returns. As a result, there is less surprise when the events happen in the future, and marketwise information is attributed to a larger proportion of the overall return variation. The moderator effects of analyst coverage, stock turnover, and group holding further reinforce the role of informativeness. Specifically, analyst coverage and stock turnover are positive indicators of informativeness and positively correlate with stock return synchronicity while negatively moderating the centrality-synchronicity relation. By contrast, group holding, a negative indicator of informativeness, negatively correlates with stock return synchronicity and positively moderates the centrality-synchronicity relation. In summary, board centrality speeds up information transmission and improves the company's information environment, leading to high stock return synchronicity. This effect is less critical when the firm's informativeness is high (high analyst coverage and stock turnover) and more critical when the firm's informativeness is low (high group holding).

Our investigation is subject to the limitation that the centrality measures are calculated via formal directorship interlocks; however, informal networks also contribute to information transmission. Even though we are limited to fully capturing the total breadth of the director's network, prior findings indicate that informal and formal networks are positively correlated (Hwang & Kim, 2009) and could be complementary to be used strategically to manage resource dependence. Therefore, the relation between board centrality and stock return synchronicity we investigated could be conservative. To conclude, we shed light on possible endeavors for further studies. First, further studies can explore how to include informal networks in overall centrality measures. The issue of whether a positive or negative centrality-synchronicity relation is beneficial or detrimental to a firm's performance and/or shareholders' wealth merits further exploration.

REFERENCES

Ahuja G (2000): The Duality of Collaboration: Inducements and Opportunities in the Formation of Interfirm Linkages. *Strategic Management Journal, 21*(3), 317-343.

Akbas F, Meschke F, Wintoki MB (2016): Director Networks and Informed Traders. *Journal of Accounting and Economics, 62*(1), 1-23.

An H, Zhang T (2013): Stock Price Synchronicity, Crash Risk, and Institutional Investors. *Journal of Corporate Finance, 21*, 1-15.

Barberis N, Shleifer A (2003): Style Investing. *Journal of Financial Economics, 68*(2), 161-199.

Barberis, N., Shleifer, A., Wurgler, J. (2005): Comovement. *Journal of Financial Economics, 75*(2), 283-317.

BarNir A, Smith KA (2002): Interfirm Alliances in the Small Business: The Role of Social Networks. *Journal of Small Business Management, 40*(3), 219-232.

Ben-Nasr H, Cosset J-C (2014): State Ownership, Political Institutions, and Stock Price Informativeness: Evidence from Privatization. *Journal of Corporate Finance, 29*, 179-199.

Benson BW, Iyer SR, Kemper KJ, Zhao J (2018): Director Networks and Credit Ratings. *Financial Review, 53*(2), 301-336.

Bizjak J, Lemmon M, Whitby R (2009): Option Backdating and Board Interlocks. *The Review of Financial Studies, 22*(11), 4821-4847.

Bonacich P (1987): Power and Centrality: A Family of Measures. *American Journal of Sociology, 92*(5), 1170-1182.

Bonacich P (2007): Some Unique Properties of Eigenvector Centrality. *Social Networks, 29*(4), 555-564.

Boyer BH, Kumagai T, Yuan K (2006): How Do Crises Spread? Evidence from Accessible and Inaccessible Stock Indices. *The Journal of Finance, 61*(2), 957-1003.

Brockman P, Yan X (2009): Block Ownership and Firm-Specific Information. *Journal of Banking & Finance, 33*(2), 308-316.

Brunninge O, Nordqvist M, Wiklund J (2007): Corporate Governance and Strategic Change in SMEs: The Effects of Ownership, Board Composition and Top Management Teams. *Small Business Economics, 29*(3), 295-308.

Carhart MM (1997): On Persistence in Mutual Fund Performance. *The Journal of Finance, 52*(1), 57-82.

Chan K, Hameed A (2006): Stock Price Synchronicity and Analyst Coverage in Emerging Markets. *Journal of Financial Economics, 80*(1), 115-147.

Chemmanur TJ, Fulghieri P (1999): A Theory of The Going-Public Decision. *The Review of Financial Studies, 12*(2), 249-279.

Chen X, Cheng Q, Lo K (2010): On the Relationship Between Analyst Reports and Corporate Disclosures: Exploring the Roles of Information Discovery and Interpretation. *Journal of Accounting Economics, 49*(3), 206-226.

Cheng S, Felix R, Zhao Y (2019): Board Interlock Networks and Informed Short Sales. *Journal of Banking & Finance, 98*, 198-211.

Chiu P-C, Teoh SH, Tian F (2013): Board Interlocks and Earnings Management Contagion. *The Accounting Review, 88*(3), 915-944.

Choi HM, Gupta-Mukherjee S (2022): Analysts' Reliance on Industry-Level Versus Firm-Specific Information: Implications for Information Production. *Journal of Banking & Finance, 143*, 106555.

Chue TK, Gul FA, Mian GM (2019): Aggregate Investor Sentiment and Stock Return Synchronicity. *Journal of Banking & Finance, 108*, 105628.

Chung KH, Zhang H (2011): Corporate Governance and Institutional Ownership. *Journal of Financial and Quantitative Analysis, 46*(1):247-273.

Crawford SS, Roulstone DT, So EC (2012): Analyst Initiations of Coverage and Stock Return Synchronicity. *The Accounting Review, 87*(5):1527-1553.

Dasgupta S, Gan J, Gao N (2010): Transparency, Price Informativeness, and Stock Return Synchronicity: Theory and Evidence. *Journal of Financial Quantitative Analysis*, 1189-1220.

Davis GF (1991): *Network and Corporate Control: Comparing Agency Theory and Interorganizational Explanations for the Diffusion of the Poison Pill.* Paper presented at the Academy of Management Proceedings.

Davis GF, Greve HR (1997): Corporate Elite Networks and Governance Changes in the 1980s. *American Journal of Sociology, 103*(1):1-37.

Dong Y, Li OZ, Lin Y, Ni C (2016): Does Information-Processing Cost Affect Firm-Specific Information Acquisition? Evidence from XBRL Adoption. *Journal of Financial and Quantitative Analysis, 51*(2):435-462.

Engle R (2002): Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models. *Journal of Business & Economic Statistics, 20*(3):339-350.

Fama EF (1980): Agency Problems and the Theory of the Firm. *Journal of Political Economy, 88*(2):288-307.

Fan JP, Wong TJ (2002): Corporate Ownership Structure and the Informativeness of Accounting Earnings in East Asia. *Journal of Accounting Economics, 33*(3):401-425.

Ferreira MA, Laux PA (2007): Corporate Governance, Idiosyncratic Risk, and Information Flow. *The Journal of Finance, 62*(2):951-989.

Forbes KJ, Rigobon R (2002): No Contagion, Only Interdependence: Measuring Stock Market Comovements. *The Journal of Finance, 57*(5):2223-2261.

Frankel R, Li X (2004): Characteristics of a Firm's Information Environment and the Information Asymmetry Between Insiders and Outsiders. *Journal of Accounting and Economics, 37*(2):229-259.

Freeman LC (1977): A Set of Measures of Centrality Based on Betweenness. *Sociometry*, 35-41.

Gassen J, Skaife HA, Veenman D (2020): Illiquidity and the Measurement of Stock Price Synchronicity. *Contemporary Accounting Research, 37*(1):419-456.

Gul FA, Srinidhi B, Ng AC (2011): Does Board Gender Diversity Improve the Informativeness of Stock Prices? *Journal of Accounting Economics, 51*(3):314-338.

Ho TS, Michaely R (1988): Information Quality and Market Efficiency. *Journal of Financial and Quantitative Analysis, 23*(1):53-70.

Hochberg YV, Ljungqvist A, Lu Y (2007): Whom You Know Matters: Venture Capital Networks and Investment Performance. *The Journal of Finance, 62*(1):251-301.

Hong H, Lim T, Stein JC (2000): Bad News Travels Slowly: Size, Analyst Coverage, and the Profitability of Momentum Strategies. *The Journal of Finance, 55*(1):265-295.

Horton J, Millo Y, Serafeim G (2012): Resources or Power? Implications of Social Networks on Compensation and Firm Performance. *Journal of Business Finance & Accounting, 39*(3-4):399-426.

Hutton AP, Marcus AJ, Tehranian H (2009): Opaque Financial Reports, R2, and Crash Risk. *Journal of Financial Economics, 94*(1):67-86.

Hwang B-H, Kim S (2009): It Pays to Have Friends. *Journal of Financial Economics, 93*(1):138-158.

Intintoli VJ, Kahle KM, Zhao W (2018): Director Connectedness: Monitoring Efficacy and Career Prospects. *Journal of Financial and Quantitative Analysis, 53*(1):65-108.

Janney JJ, Gove S (2017): Firm Linkages to Scandals Via Directors and Professional Service Firms: Insights from the Backdating Scandal. *Journal of Business Ethics, 140*(1):65-79.

Javakhadze D, Rajkovic T (2019): How Friends with Money Affect Corporate Cash Policies? The international evidence. *European Financial Management, 25*(4):807-860.

Jin L, Myers SC (2006): R2 around the World: New Theory and New Tests. *Journal of Financial Economics, 79*(2):257-292.

Kelly PJ (2014): Information Efficiency and Firm-Specific Return Variation. *The Quarterly Journal of Finance, 4*(04):1450018.

Khanna T, Thomas C (2009): Synchronicity and Firm Interlocks in an Emerging Market. *Journal of Financial Economics, 92*(2):182-204.

Kim J-B, Shi H (2012): Voluntary IFRS Adoption, Analyst Coverage, and Information Quality: International Evidence. *Journal of International Accounting Research, 11*(1):45-76.

Larcker DF, So EC, Wang CC (2013): Boardroom Centrality and Firm Performance. *Journal of Accounting and Economics, 55*(2-3):225-250.

Liu MH (2011): Analysts' Incentives to Produce Industry-Level versus Firm-Specific Information. *Journal of Financial and Quantitative Analysis, 46*(3):757-784.

Morck R, Shleifer A, Vishny RW (1988): Management Ownership and Market Valuation: An Empirical Analysis. *Journal of Financial Economics, 20*:293-315.

Morck R, Yeung B, Yu W (2000): The Information Content of Stock Markets: Why Do Emerging Markets Have Synchronous Stock Price Movements? *Journal of Financial Economics, 58*(1):215-260.

Piotroski JD, Roulstone DT (2004): The Influence of Analysts, Institutional Investors, and Insiders on the Incorporation of market, Industry, and Firm-Specific Information into Stock Prices. *The Accounting Review, 79*(4):1119-1151.

Rao H, Davis GF, Ward A (2000): Embeddedness, Social Identity and mobility: Why Firms Leave the NASDAQ and Join the New York Stock Exchange. *Administrative Science Quarterly, 45*(2):268-292.

Shivdasani A (1993): Board Composition, Ownership Structure, and Hostile Takeovers. *Journal of Accounting and Economics, 16*(1):167-198.

Sila V, Gonzalez A, Hagendorff J (2017): Independent Director Reputation Incentives and Stock Price Informativeness. *Journal of Corporate Finance, 47*:219-235.

Tao Q, Li H, Wu Q, Zhang T, Zhu Y (2019): The Dark Side of Board Network Centrality: Evidence from Merger Performance. *Journal of Business Research, 104*:215-232.

Tsai W, Ghoshal S (1998): Social Capital and Value Creation: The Role of Intrafirm Networks. *Academy of Management Journal, 41*(4):464-476.

Vafeas N (1999): Board Meeting Frequency and Firm Performance. *Journal of Financial Economics, 53*(1):113-142.

Veldkamp LL (2006): Information Markets and the Comovement of Asset Prices. *The Review of Economic Studies, 73*(3):823-845.

Wen F, Yuan Y, Zhou WX (2021): Cross-Shareholding Networks and Stock Price Synchronicity: Evidence from China. *International Journal of Finance Economics, 26*(1):914-948.

Yermack D (2004): Remuneration, Retention, and Reputation Incentives for Outside Directors. *The Journal of Finance, 59*(5):2281-2308.

Yu FF (2008): Analyst Coverage and Earnings Management. *Journal of Financial Economics, 88*(2):245-271.