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CFO social networks and corporation taxation

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ABSTRACT

Despite the significance of social networks in influencing firm behavior, research on their impact on corporate tax behavior is limited. In this paper, we construct social networks of CFOs from U.S. companies based on their employment history, education, and non-professional activities. We find that firms with more socially connected CFOs have lower effective tax rates (ETR) compared to firms with less socially connected CFOs. This effect is more pronounced when corporate governance is weaker and managers have higher incentives. Furthermore, a firm's ETR decreases as CFO centrality increases. We do not observe similar results regarding the connectedness of boards of directors. Additionally, firm pairs exhibit similar ETRs when their CFOs are socially connected, suggesting an exchange of tax-related information among CFOs through their social networks. We also find that the past ETRs of firms with central CFOs predict the ETRs of firms with non-central CFOs. This indicates that less socially connected CFOs tend to follow the tax planning strategies of their more socially connected counterparts. Overall, our findings indicate that more socially connected CFOs possess more relevant information and resources regarding tax planning, leading to the adoption of more aggressive tax strategies compared to their less socially connected counterparts.

1. Introduction

Corporate tax avoidance is a significant research topic, as evidenced by numerous studies linking it to firm characteristics (e.g., Cheng et al., 2012, Rego and Wilson, 2012, McGuire et al., 2014, Armstrong et al., 2015, Henry and Sansing, 2018, Chen et al., 2019; Edeigba et al., 2023). Concurrently, academicians, practitioners, and commentators (e.g., Hanlon and Heitzman, 2010, Wang et al., 2020, Burhan et al., 2023) suggest that the influence of social networks on tax avoidance warrants investigation, as emerging literature has documented that social networks affect firm behavior in various ways (e.g., Hochberg et al., 2007, Cohen et al., 2008, Stuart and Yim, 2010, Cai and Sevilir, 2012, Fracassi and Tate, 2012, Huang and Wang, 2020, Fang et al., 2021, Cheng et al., 2024). However, to date, little is understood about the relationship between social networks and tax avoidance, partly due to challenges related to data and measurement.

In this paper, we focus on the social networks of CFOs, the senior executives responsible for managing financial actions and overseeing all taxation issues within their companies. Previous studies indicate that a CFO's personal characteristics significantly influence corporate tax avoidance (e.g., Francis et al., 2014, Hsieh et al., 2018, Chen et al., 2020). Building on the literature regarding the different roles of CFOs and other executives in corporate decisions (e.g., Chava and Purnanandam, 2010, Jiang et al., 2010, Krishnan et al., 2011, Friedman, 2014, Francis et al., 2015, Baker et al., 2019, Khedmati et al., 2020, Ege et al., 2021), we posit that CFOs' social networks play a significant role in shaping corporate tax avoidance strategies.

Social networks influence corporate behavior by facilitating the diffusion of information and resources among networked individuals (e.g., Bizjak et al., 2009, Fracassi, 2017, Fang et al., 2022, Bianchi et al., 2023). Consequently, CFOs who are centrally located within social networks may possess an information advantage over others, as central CFOs are exposed to more information (Fracassi, 2017, Fang et al., 2022). Central CFOs may also wield greater negotiating power, influence, and fewer constraints, as their network positions provide them with more resources and alternative opportunities (e.g., Fracassi and Tate, 2012, Engelberg et al., 2013, Bianchi et al., 2023). Following this line of reasoning, we expect that firms with CFOs who are more central in the network may engage in more tax avoidance behavior, as these CFOs are exposed to a wider array of tax avoidance strategies and may

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incur lower costs when engaging in aggressive tax planning.

Alternatively, firms with CFOs who are more central in the social network may engage in less tax avoidance behavior due to the significant reputational costs these CFOs face associated with such actions. Regulators and public scrutiny place significant emphasis on the tax planning behaviors of firms (Shulman, 2009). Moreover, when making decisions, CFOs often prioritize their reputation (Breza and Chandrasekhar, 2019). In a central position within the social network, CFOs face greater exposure to external scrutiny, which heightens public pressure and negatively impacts their intentions to avoid taxes. This opposing argument transforms our research question into an empirical question.

Our sample is constructed from the biographical information of CFOs provided in BoardEx. We assemble a set of social, educational, and professional network matrices for all CFOs in the BoardEx universe. These social ties are tracked over the span of 11 years, from 2000 to 2010. Similarly, we construct a network of top executives and directors for the purpose of comparison. The final sample for our main test contains 11,303 firm year observations for 1824 firms for the period 2000–2010. Using this sample, we explore 1) whether CFO centrality impacts firm tax avoidance, and 2), if yes, through what channels.

Following Larcker et al. (2013), we construct an "overall" measure, *NScore*, to capture the centrality of a firm's CFO in the social networks. *NScore* is an aggregated measure based on four dimensions of centrality, including degree centrality, betweenness centrality, closeness centrality, and eigenvector centrality. We examine how *NScore* affects tax avoidance after controlling for board connections, firm time-variant characteristics, industry fixed effects, and year fixed effects. Following the prior literature (e.g., Dyreng et al., 2010, Cheng et al., 2012, Hasan et al., 2017), we use effective tax rate (ETR) to measure the overall level of tax avoidance. We find that firms with CFOs that occupy more central positions in social networks have significantly lower ETR than firms whose CFOs are less connected. The effect is also economically significant. In our baseline model, we find that a one standard deviation increase in *NScore* is associated with about 1.42 % decrease in ETR.

Importantly, we argue that a causal relationship likely exists between social network centrality and ETR. First, the centrality measure is lagged by one year relative to the dependent variable, which at least alleviates concerns of contemporaneous endogenous effects. Second, past employment and education connections are formed during CFOs' past experiences, long before they make tax decisions in the current firms. Thus, it is hard to argue a reverse causality story where social connections are driven by ETR. Third, we use a change regression model and examine how tax avoidance changes after CFO centrality changes. We find that the ETR of a firm decreases after the CFO centrality of the firm increases. Collectively, the findings indicate that more central CFOs adopt more aggressive tax strategies than less central CFOs.

We further examine why CFO social networks affect tax avoidance. We propose two channels based on the social network theory: 1) the information exchange through social networks gives central CFOs an information advantage and therefore a broad set of tax tools and strategies to choose from, and 2) the wider exposure to resources and opportunities allows central CFOs excess power and thus less restrictions or potential costs associated with aggressive tax behavior.

We first test the information exchange on the CFO's social networks. We argue that if our findings are driven by information exchange through CFOs social networks, we should expect firm pairs whose CFOs are directly connected to each other who have similar ETRs. To test this mechanism, we investigate the pairwise connections of CFOs with a two-stage gravity model. We find statistically and economically significant evidence that firms have similar ETRs if their CFOs are socially connected, supporting the argument for the information exchange channel.

We then examine the direction in which information flows between more central and less central CFOs. We estimate two Granger causality models simultaneously to test if the past ETRs of firms with more central CFOs predict the future ETRs of firms with less central CFOs or vice versa. We find that the ETRs of firms with less central CFOs are predicted by the lagged ETRs of their central CFO connections. However, the ETRs of central CFOs are not predicted by the ETRs of their non-central CFO connections. These findings suggest that non-central CFOs follow the tax strategies of central CFOs but not the other way around. Importantly, these findings are consistent with our argument that more central CFOs have more power and influence than less central CFOs.

For robustness checks, we construct degree centrality, betweenness centrality, closeness centrality, eigenvector centrality, and their normalized forms as alternative measures of centrality. We find our main results hold for degree, betweenness, and closeness centrality measures. In addition, we find that our results are robust after including an additional control variable for CFO-Auditor social ties. Furthermore, we perform the same tests using the social networks of CEOs and other top executives. Consistent with the results from CFOs' networks, we find that the higher centrality of CEOs and other top executives is also associated with lower ETR.

Finally, we examine the moderating effects of corporate governance and managerial incentives on the relationship between CFO social networks and tax avoidance. Managers may exhibit more aggressive tax behavior when corporate governance is weaker (e.g., Desai and Dharmapala, 2006, Allen et al., 2016; Mansi et al., 2020) and when their compensation contracts are closely tied to firm performance (Armstrong et al., 2015). To test these two effects, we partition the sample based on whether the proxies exceed the industry median for all firms in each year. We find that firms with weaker corporate governance and greater managerial incentives exhibit more tax avoidance behavior when CFO social networks are stronger.

Our paper makes two major contributions to the literature. Foremost, this paper contributes to the literature on the determinants of tax avoidance.[1] Previous literature examines how corporate tax avoidance is influenced by board ties (Hope et al., 2013, Brown and Drake, 2014[2]), corporate political ties (Kim and Zhang, 2016), and supply-chain ties (Cen et al., 2017). We connect the literature on tax avoidance and executives' social networks, directly responding to the call in Hanlon and

[1] Prior studies on the determinants of tax avoidance examine both internal and external factors. Internal factors include firm-level characteristics (Rego, 2003, Wilson, 2009, Lisowsky, 2010, Hope et al., 2013, Higgins et al., 2015, Hasan et al., 2024), ownership structure (Desai and Dharmapala, 2009, Khan et al., 2017), corporate governance (Lanis and Richardson, 2011, Richardson et al., 2013, Armstrong et al., 2015, Gallemore and Labro, 2015, Allen et al., 2016, Bauer, 2016), executives' personal characteristics and compensation plans (Rego and Wilson, 2012, Bauer, 2016, Law and Mills, 2017, Francis et al., 2022); external factors include institutional factors (Desai et al., 2007; Hoopes et al., 2012), external market conditions (Kubick et al., 2015, Edwards et al., 2016, Chen et al., 2022), external governance (Tian et al., 2016, Kanagaretnam et al., 2018, Fan and Chen, 2023), and social networks (Hope et al., 2013, Brown and Drake, 2014, Kim and Zhang, 2016, Cen et al., 2017).

[2] Our paper is different from Brown and Drake (2014) in the following ways. First, while Brown and Drake (2014) investigate whether board ties to low-tax firms impact the focal firm's tax avoidance behavior, our paper examine the impact of a focal firm's CFO social connections on tax avoidance behavior. Second, Brown and Drake (2014) find that firms with greater board ties to low-tax firms have lower cash ETRs. Our paper finds that firms with more socially connected CFOs have lower ETR than firms with less socially connected CFOs. In addition, our power channel test indicates that those CFOs with less power in the social connection will follow those who have more power. Our results corroborate the Brown and Drake (2014)'s findings that firms with greater connection power in the social network could serve as a "learning model" for those who have less power. Third, Brown and Drake (2014) use board interlocks to proxy for a firm's network ties to low-tax firms. We employ four commonly used centrality measures and subsequently construct an aggregated measure based on them. While Brown and Drake (2014) capture the relationship between the board of the focal firm and its low-tax peers, we directly capture how the social connections of the focal firm's executives influence the firm's tax avoidance behavior.

Heitzman (2010) for research on the role of social networks in determining tax avoidance. To the best of our knowledge, this is the first paper to provide empirical evidence that CFOs' centrality within their networks is significant for corporate tax avoidance.

Second, this paper contributes to the literature on the impact of social networks on corporate decision-making. Previous studies document that social networks influence firm decisions, behavior, and performance in various ways (e.g., Hochberg et al., 2007, Cohen et al., 2008, Stuart and Yim, 2010, Cai and Sevilir, 2012, Fracassi and Tate, 2012, Chiu et al., 2013, Larcker et al., 2013, Cai et al., 2014, Schabus, 2022). However, the literature offers a limited understanding of how interactive social links influence firms' tax-related decisions. Our findings indicate that social networks play a crucial role in firms' tax avoidance decisions. This paper addresses a gap in the social network literature.

The remainder of the paper is structured as follows: Section 2 presents the literature review and hypothesis development; Section 3 contains descriptions of the data and the variables; Section 4 presents primary empirical findings; Section 5 presents additional analysis; and Section 6 concludes.

2. Literature review and hypothesis development

Social networks are formed by individuals (nodes) and their connections (links). The positions of nodes in the network are not equal, and positions gain power when they (1) link to more individuals; (2) are on the shortest path connecting other pairs of individuals; (3) are close to all other individuals; and (4) are linked to more individuals who are themselves highly linked (El-Khatib et al., 2015). Such powerful positions are central in social networks, and central positions have at least two implications. First, social network connections can facilitate information flows between individuals or companies, and therefore, central positions would be exposed to more information. For example, Hochberg et al. (2007) find that better-networked venture capital (VC) firms experience better fund performance, and the portfolio companies of better-networked VCs are more likely to survive subsequent financing and eventual exit. Cohen et al. (2008) find that mutual fund managers invest more and perform significantly better on stock holdings for which the board members go to school together with the mutual fund managers, suggesting that social networks are an important mechanism for information flow into asset pricing. Cohen et al. (2010) find evidence in support of the impact of social networks on agents' ability to gather superior information about firms by exploiting the educational backgrounds of sell-side analysts and senior corporate officers. Brown et al. (2008) provide evidence of a causal relationship between an individual's decision to own stock and the average stock market participation of the individual's home community. Fracassi (2017) studies the investment levels of firms and finds that managers are influenced by their social peers when making investment and other corporate finance decisions. More recently, Dharwadkar et al. (2020) find that audit committee interlocks are associated with contagion in reported special items.

Second, social networks could exacerbate agency problems and weaken corporate governance, with the effect more pronounced for central positions. Hwang and Kim (2009) distinguish directors that are conventionally independent and socially independent and suggest that social ties matter in corporate governance by showing that firms whose boards are conventionally and socially independent award a significantly lower level of compensation and exhibit stronger pay-performance sensitivity and stronger turnover-performance sensitivity than firms whose boards are only conventionally independent. A study by Krishnan et al. (2011) finds that CFOs/CEOs pick more socially connected directors in the post-Sarbanes-Oxley Act (SOX) time period (possibly as a way out of the mandated independence requirements), and CFO/CEO-board ties lead to increased earnings management activities. Cheng et al. (2019) find that firms are less likely to report an internal control material weakness (as mandated by the Sarbanes-Oxley Act) in a given year if one of their audit committee members is concurrently on the board of a firm that disclosed a material weakness within the prior three years.

Drawing on the arguments in social network theory, we expect that firms with better connected CFOs would have more information and resources that facilitate their tax avoidance activities. On the one hand, central CFOs would have better access to information and knowledge -explicit or implicit- to aid tax avoidance because their central positions give them greater exposure to information and more opportunities to learn vicariously from others. On the other hand, central individuals may also have more resources and tools available through reciprocal relationships to avoid taxes. They could, for example, find it easier to implement certain tax avoidance techniques if they have friendly connections with the related parties.

From the governance perspective, the costs of the aggressive tax avoidance behavior of central individuals could be lower due to their expanded resources and opportunities. For example, Fracassi and Tate (2012) find that external network connections between directors and CEOs weaken the intensity of board monitoring. He et al. (2017) find that social ties between engagement auditors and audit committee members impair audit quality. Well-connected firms and executives incur lower costs from government regulations as well. For instance, Correia (2014) finds that politically connected firms on average are less likely to be involved in SEC enforcement actions and face lower penalties if they are prosecuted by the SEC. Kim and Zhang (2016) show that politically connected firms are more tax-aggressive than non-connected firms.

Accordingly, the collective argument of the social network theory suggests that firms with more socially connected CFOs have more information and resources to engage in tax avoidance and face fewer negative consequences from their tax avoidance behavior. Therefore, we propose the following hypothesis:

H1A. : *CFO centrality is positively associated with firm tax avoidance.*

Although we expect a positive relationship between the CFO centrality and corporate tax behavior, there is still a possibility that CFO centrality may limit tax avoidance behavior due to concerns about reputation. The Commissioner of the Internal Revenue Service (IRS) claims that employing aggressive tax methods can present a substantial threat to company reputations. Furthermore, the Commissioner states that "the general public has limited tolerance for excessively aggressive tax planning (Shulman, 2009)." Empirical evidence also highlights the issue of reputational concern in tax avoidance decisions. Graham et al. (2014) survey tax executives and find that over 50 % of them believe that potential harm to their firm's reputation is an important factor in deciding whether or not to adopt a tax planning strategy. Moreover, CFOs with a higher level of social connection are more concerned about their reputation (Breza and Chandrasekhar, 2019). This evidence is consistent with the perception that CFOs with higher social centrality care more about their reputations and thus they tend to perceive that engaging in aggressive tax avoidance will result in reputational repercussions for themselves or their organizations. As a result, they are less likely to engage in tax avoidance.

H1B. *: CFO centrality is negatively associated with firm tax avoidance.*

Social network and economic theory also suggest that local neighbors in a social network influence each other's decisions and behavior (Kilduff and Tsai, 2003). On the one hand, according to bounded rationality, people have constraints on their ability to process or obtain costly information (Simon, 1987). Therefore, rational observers may follow the behavior of others based on communication about the rationale of the action or observation of the action or the outcome (Ellison and Fudenberg, 1993, 1995, Chiu et al., 2013). On the other hand, people may imitate others in order to conform or due to peer pressure. For example, Luttmer (2005) finds that individuals place utility on relative income and feel worse off when others around them earn more. Brown et al. (2008) find a causal relation between an individual's decision to own stock and the average stock market participation of the individual's home community, suggesting the influence of the community effect in the form of word-of-mouth communication. Fracassi (2017) finds that the more connections two companies share with each other, the more similar are their capital investments and other corporate finance policies are.

The implications of the theory for tax avoidance are twofold. First, socially connected managers might make their tax avoidance decisions rationally based on what they learn from each other in a social network, resulting in herding. Second, interactions between socially connected managers could induce envy, resulting in efforts to "keep up with the Joneses" when making tax-related decisions. Based on these arguments, we propose the following hypothesis:

H2. : *Socially connected firm pairs have more similar tax avoidance compared to socially unconnected firm pairs.*

3. Sample construction and variable measurement

3.1. Sample construction

We use social network data from Boardex of Management Diagnostics Limited, which supplies biographical information on employment, education, and other activities for managers and board directors. We start with all CFOs (or later all directors and top executives) of U.S. firms (financial and utility industries excluded) in the BoardEx universe and define three networks representing different social interactions among individuals as follows:[3]

- We identify a work tie if they worked in the same public or non-public firm at the same time on the board of directors or as a high-level manager within three preceding years.
- We identify a school tie between two individuals if they went to the same school and graduated within one year of each other with the same professional, master's, or PhD degree.[4]
- Other social ties are identified if two individuals maintain membership in the same country clubs, or serve the same charity, university, government, army, or other non-profit association and have active roles in these organizations within three preceding years.

Using the biographical information for CFOs (or top executives and directors), we build a 315,242 by 315,242 adjacency matrix, $A = \{a_{ij}\}$, for each of the three networks each year for the period 2000–2010, with elements defined by

$$a_{ij} = \begin{cases} 1\text{if a network tie of the type is identified} \\ 0\text{otherwise} \end{cases}$$

These matrices represent social connections that exist among individual CFOs (or executives and directors) in the sample. Individual connections are then aggregated by company pairs according to employment data: two firms are socially connected if CFOs (or at least two individual executives or directors) of these companies are socially connected. For each type of networks of companies each year, we create an 8783 by 8783 adjacency matrix. Fig. 1 presents the social network of firms by the end of 2010 that arises from executive and director's educational experiences.

Social network data are then merged with annual accounting data for U.S. firms from COMPUSTAT and corporate governance data from IRRC. Following prior literature (e.g., Badertscher et al., 2013, Bonsall et al., 2017, Arena et al., 2021) on tax avoidance, we exclude utilities (SIC codes 4900–4949) and finance companies (SIC codes 6000–6999). Following the literature, we require 1) market value to be greater than 10 million to exclude small firms and 2), at least eight firms per two-digit SIC industry per year to ensure identification of tax avoidance measures. All accounting data are winsorized at the 0.01 level. The final sample for the main test contains 11,303 firm year observations for 1824 firms for the period 2000–2010.

3.2. Centrality measure

Centrality measures the overall embeddedness of an individual firm in the network that consists of all firms. In the context of this paper, centrality measures help to quantify how connected a firm is to the social network of companies. We choose four commonly used centrality measures and then construct an aggregated measure based on them. The individual centrality measures include degree, betweenness, closeness, eigenvector, and their corresponding normalized measures.

Degree Centrality is the sum of all links that a firm has with other companies in the network. It was first suggested by Proctor and Loomis (1951) to indicate how active a node is. The normalized degree *CD(x)* of a node x is the sum of all links that a firm has with other companies in the network divided by the number of companies in the network.

Betweenness Centrality is the sum of probabilities across all possible company pairs that the shortest path between the two companies passes through the firm. The betweenness centrality measure was introduced by Freeman (1977) to indicate a person's ability to act as an intermediary, bringing people together. A person is central, if he or she lies on several of the shortest paths among other pairs of persons. Such people have control over the flow of information in the network. The absolute betweenness of a node x is defined by

$$C_B(x) = \sum_{y<z} \frac{m(y,z;x)}{m(y,z)} \tag{1}$$

where $m(y, z; x)$ is the number of shortest paths between y and z through unit x, and $m(y, z)$ is the number of shortest paths between y and z.

Closeness Centrality is the inverse of the sum of graph theoretical distances to all other companies from the firm. The closeness centrality measure indicates a person's ability to quickly interact with all others on the network. This measure, offered by Sabidussi (1966), is different from degree centrality because it considers not only direct connections among units but also indirect connections. The absolute closeness of a node x is defined by

$$C_C(x) = \frac{1}{\sum_{y \epsilon U} d(x,y)} \tag{2}$$

where U represents the set of all nodes on the network, and $d(x, y)$ is the number of edges in a shortest path connecting units x and y.

Eigenvector Centrality is a measure of the influence of a node in a network. It assigns relative scores to all nodes in the network based on the concept that connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes. The centrality score of the node x can be defined as

$$C_E(x) = \frac{1}{\lambda} \sum_{y \in U} a_{x,y} C_E(y) \tag{3}$$

where U represents the set of all nodes on the network, λ is a constant, and $a_{x,y}$*equals one* if node x is linked to node y, and zero otherwise. With a small rearrangement this can be rewritten in vector notation as the eigenvector equation $Ax = \lambda x$.

[3] Boardex provides information also on mid-level management, with biographical information gathered from publicly-available sources. Following Fracassi (2017), we limit my analysis to top executives and directors for two reasons: First, to avoid introducing sample selection biases due to the heterogeneity in the optional disclosure policy among companies. Second, mid-level management are less involved in the earnings management decisions.

[4] Following Fracassi (2017), academic degrees generically indicated as Bachelor, BS, BA, MA or MS do not qualify as social connections. We use masters or professional degrees, such as MBA, JD or MD, to maximize the probability that the individuals actually met as a result of the shared education.

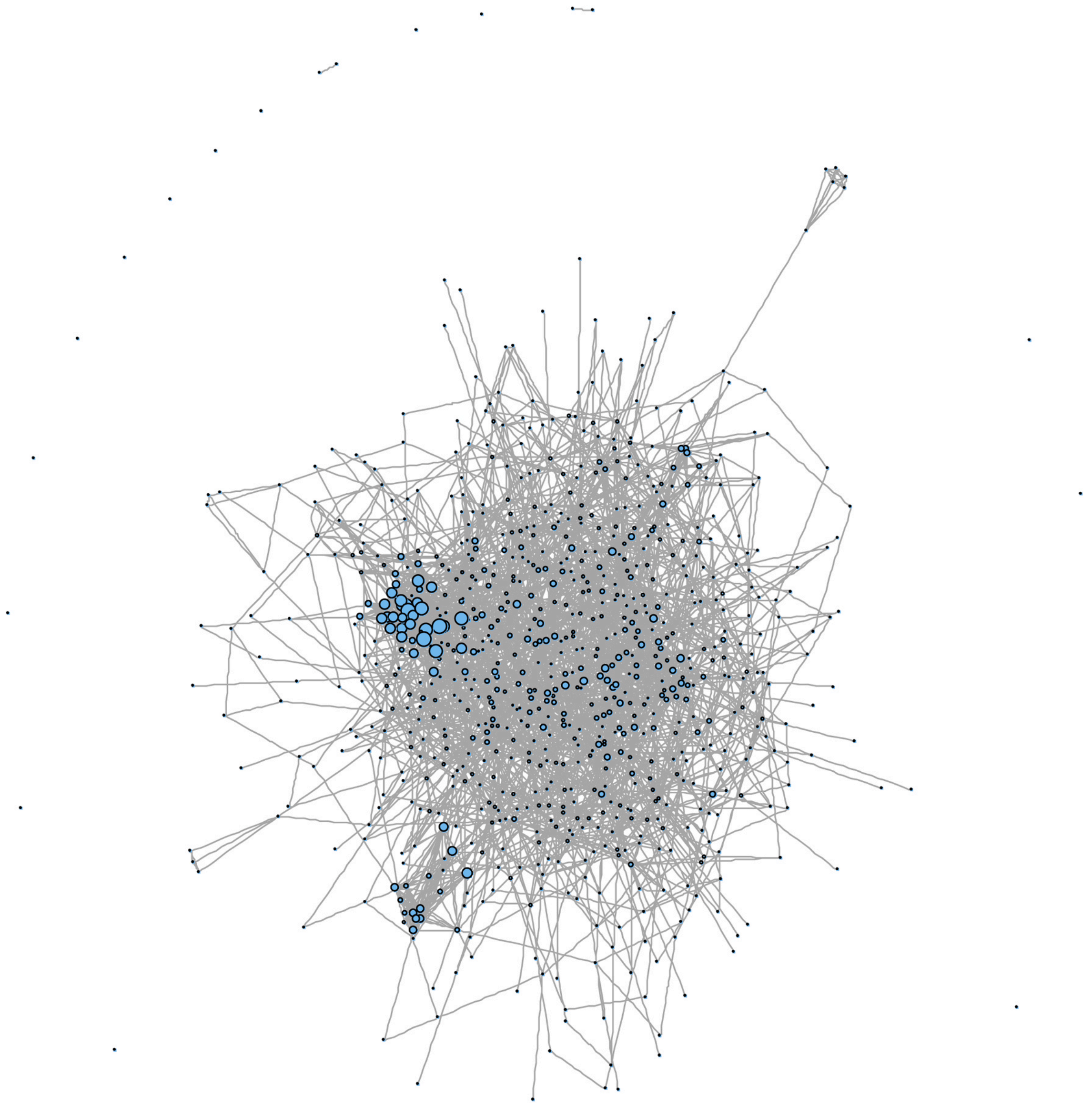

Fig. 1. Social Network of US Companies (2010). This is a visualization of the network of US firms. For the sake clarity, we only plotted firms that are between the 45 and 55 percentiles according to their degree centrality. Therefore, the graph shows the social network of medium firms. Nodes in the figure represent companies and the size of the node represents the degree centrality of the company. Links represent social network connections among companies that arise from experiences of executives and directors occurred by the end of 2010.

The aforementioned measures capture different aspects of centrality. However, there is a concern that larger firms tend to have more connections than smaller firms, giving rise to a mechanically positive relation between firm size and measures of centrality (Larcker et al., 2013). To separate the effects of size and CFO social connection on tax avoidance, we create ranked versions of the centrality measures that attempt to purge such measures of their associations with size. Following Larcker et al. (2013), we create an "overall" measure of centrality with consideration of the size effect. Specifically, we rank all firms into quintiles based on the log market value of equity (denoted as *SIZE*). Within each *SIZE* quintile, we sort firms into quintiles based on the four centrality measures: degree (*DEG*), betweenness (*BET*), closeness (*CLOSENESS*), and eigenvector (*EIG*), where the highest values of centrality assume a value of five and the lowest assumes one. The application of quintile ranks mitigates the effect of outliers, enhances the interpretability of regression outcomes, aids in portfolio construction for cross-sectional return forecasting, and offers a non-parametric approach to partially account for the influence of firm size on our network metrics. We then define a composite network score for each board ("*NScore*") by taking the equal-weighted average quintile rank in each of the four aforementioned centrality measures, rounded to the nearest integer as follows.

$$NScore = \frac{Quint(DEG) + Quint(BET) + Quint(CLOSENESS) + Quint(EIG)}{4} \tag{4}$$

3.3. Tax avoidance measures

Dyreng et al. (2010) define tax avoidance as "broadly to encompass anything that reduces the firm's taxes relative to its pretax accounting income". Consistent with Dyreng et al. (2010) definition, Hanlon and Heitzman (2010) also note that tax avoidance represents a continuum of tax planning strategies, including not only legal tax avoidance activities such as municipal bond investments but also aggressive forms of tax avoidance activities such as tax sheltering and tax evasion. In this paper, we are interested in *all* tax strategies (including both certain and

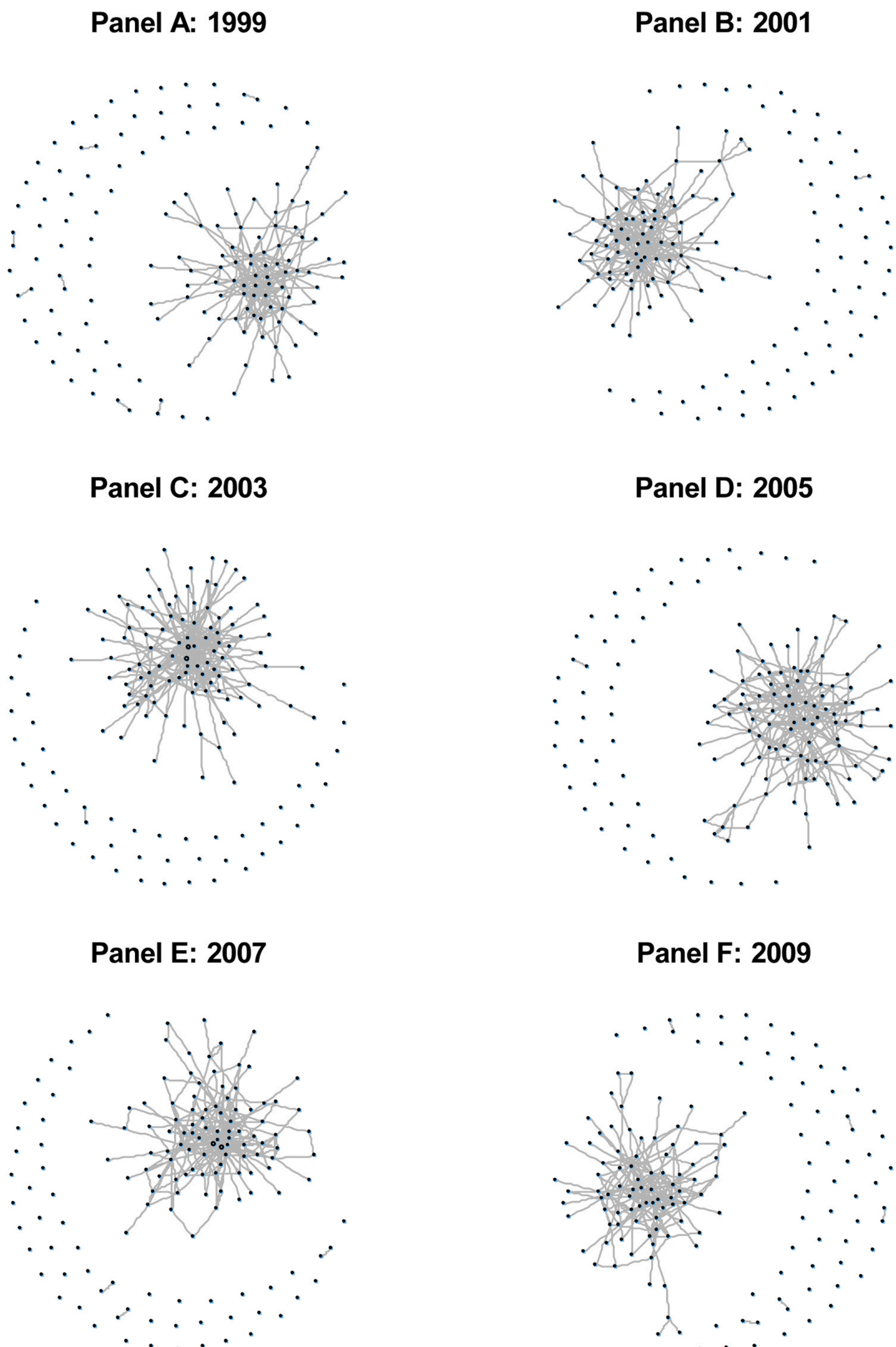

Fig. 2. Social Network of US Companies (1999–2009). This is a visualization of the network of US firms. For the sake clarity, we randomly sample 150 firms each year. Nodes in the figure represent companies and the size of the node represents the degree centrality of the company. Links represent social network connections among companies that arise from experiences of executives and directors occurred by the end of the year.

aggressive tax avoidance) that a firm can implement to reduce its taxes relative to its pretax accounting income. Therefore, the effective tax rate (ETR) is an ideal measure of tax avoidance for our study, because it is widely used as a proxy for broad tax avoidance (e.g., Cheng et al., 2012, McGuire et al., 2014, Armstrong et al., 2015, Hasan et al., 2017; Hasan et al., 2024). Following Dyreng et al. (2010), *E*TR is defined as total income tax expense (*TXT*) divided by pre-tax book income (*PI*) before special items (*SPI*). *E*TR is set as missing when the denominator is zero or negative. We truncate *E*TR to the range [0,1].

3.4. Control variables

Following the tax avoidance literature (e.g., Hanlon and Heitzman, 2010, Brown and Drake, 2014; Hasan et al., 2017), we control for the following variables: firm size (*SIZE*), market-to-book ratio (*MB*), firm performance (*ROA*), leverage (*LEV*), property, plant, and equipment (*PPE*), intangible assets (*INTAN*), research and development (*RD*), net operating loss (*NOL*), foreign income (*FI*), discretionary accruals (*ABS_DA*), corporate governance (*EINDEX* as in Bebchuk et al., 2009),

Table 1
Descriptive Statistics.

Panel A: Summary statistics						
Variables	N	Mean	Std. Dev	P1	Median	P99
Tax avoidance measures						
ETR	9689	0.298	0.158	0.000	0.324	1.000
Social network measures						
NScore	11303	2.112	1.414	1.000	1.000	5.000
DEGREE	11303	2.054	3.428	0.000	0.000	16.000
BET	11303	566.102	3984.333	0.000	0.000	15738.825
CLOSNESS	11303	0.000	0.000	0.000	0.000	0.000
EIG	11303	0.002	0.020	0.000	0.000	0.041
BD_CONN	11303	242.164	305.052	1.000	128.000	1418.000
Controls						
SIZE	11303	7.439	1.510	4.057	7.310	10.812
MB	11303	1.947	1.134	0.748	1.600	7.069
ROA	8535	0.100	0.110	−0.210	0.091	0.487
LEV	11303	0.188	0.167	0.000	0.173	0.745
PPE	11257	0.517	0.354	0.038	0.431	1.586
INTAN	11303	0.183	0.188	0.000	0.127	0.780
RD	11303	0.033	0.055	0.000	0.004	0.262
NOL	11303	0.385	0.487	0.000	0.000	1.000
FI	11303	0.019	0.037	−0.067	0.001	0.170
ABS_DA	11263	0.065	0.099	0.001	0.041	0.421
EINDEX	11303	2.532	1.411	0.000	3.000	6.000
CFO_DELTA	7014	122.547	231.619	0.000	58.000	976.000

Panel B Correlation							
		1	2	3	4	5	6
1	ETR	1.00					
2	NScore	−0.06***	1.00				
3	DEG	−0.05***	0.82***	1.00			
4	BET	−0.02**	0.27***	0.43***	1.00		
5	CLOSENESS	0.01	0.64***	0.46***	0.05***	1.00	
6	EIG	−0.02*	0.18***	0.38***	0.14***	0.12***	1.00

The data set contains 11,303 firm year observations for 1824 firms for the period 2000–2010. Panel A presents the descriptive statistics. Panel B reports the correlation matrix. Appendix provides detailed definitions and measurements for all variables. * indicates significance at 10 % level, ** significance at 5 %, *** significance at 1 %.

and CFO incentive (*CFO_DELTA*). Prior studies show that board connections are important for firm performance and corporate decision-making (e.g., Larcker et al., 2013), therefore, we also control for board connections (*BD_CONN*) in our model. Variable definitions can be found in the Appendix.

3.5. Summary statistics

Table 1 Panel A contains summary statistics for all key variables. A typical CFO in the sample has two social network connections. Tax avoidance measures and control variables are comparable with what has been documented in the literature. For example, the mean value of *ETR* is 0.298, which is similar to the value reported in Hasan et al. (2017). Panel B reports the correlation matrix of social network and tax avoidance variables. The negative and significant correlation between *ETR* and *NScore* indicates a positive relationship between social networks and tax avoidance, providing preliminary evidence supporting our Hypothesis 1.

4. Primary analysis

4.1. Does CFO centrality matter for tax avoidance?

To test Hypothesis 1, we use multivariate regression to control for possible confounding factors. We estimate the following OLS model:

$$ETR_{i,t} = \beta_0 + \beta_1 NScore_{i,t-1} + \beta_2 SIZE_{i,t-1} + \beta_3 MB_{i,t-1} + \beta_4 ROA_{i,t-1} + \beta_5 LEV_{i,t-1} + \beta_6 PPE_{i,t-1} + \beta_7 INTAN_{i,t-1} + \beta_8 RD_{i,t-1} + \beta_9 NOL_{i,t-1} + \beta_{10} FI_{i,t-1} + \beta_{11} ABS\_DA_{i,t-1} + \beta_{12} EINDEX_{i,t-1} + YEAR\_FE + INDUSTRY\_FE + \epsilon_{i,t} \tag{5}$$

where CFO centrality is represented by *NScore*. We include a measure of firm size (*SIZE*) because larger firms have access to tax planning strategies that might exhibit economies of scale (Rego, 2003), and size is a proxy for tax planning sophistication (Hanlon, 2005). We also control for market-to-book ratio (*MB*), leverage (*LEV*), capital intensity (*PPE*), intangible assets (*INTAN*), research and development activities (*RD*), and foreign income (*FI*) because prior research suggests that firm complexity and firm operations are associated with varying opportunities to avoid taxes (Gupta and Newberry, 1997, Rego, 2003). We control for profitability (*ROA*) and include an indicator variable that equals one if the firm has a net operating loss (*NOL*) reported in the previous year. Firms with low profitability and/or net operating losses likely have less incentive to engage in tax avoidance. Following Hoi et al. (2013), we control for discretionary accruals. We also control for corporate governance, as captured by *EINDEX*. We include the year fixed effect and the industry fixed effect in the model as well.

Table 2 Column 1 reports the results from estimating Eq. (5) above. Consistent with Hypothesis 1 A, the coefficient on *NSscore* is negative and significant. All else equal, firms whose CFOs are more central have significantly lower effective tax rates than firms whose CFOs are less central. The effect is also economically significant: a one standard deviation increase in *NScore* is associated with a 1.42 % (-0.003*1.414/0.298 =-1.42 %) decrease in *ETR*. The coefficients on the control variables are generally consistent with prior findings.

In Column 2, to rule out the potential effects of board connections on

Table 2
Baseline Regression: Tax Avoidance and CFO Social Network Centrality.

	(1)	(2)	(3)
	ETR	ETR	ETR
NScore	**−0.003***	**−0.003***	**−0.004*****
	(0.002)	**(0.002)**	**(0.002)**
BD_CONN		−0.000	−0.000
		(0.000)	(0.000)
SIZE	−0.002	−0.001	0.000
	(0.002)	(0.002)	(0.002)
MB	0.001	0.001	0.000
	(0.003)	(0.003)	(0.003)
ROA	0.228***	0.228***	0.252***
	(0.036)	(0.036)	(0.040)
LEV	−0.054***	−0.054***	−0.066***
	(0.017)	(0.017)	(0.019)
PPE	−0.003	−0.003	0.002
	(0.010)	(0.010)	(0.012)
INTAN	0.031**	0.031**	0.033*
	(0.016)	(0.016)	(0.018)
RD	−0.264***	−0.264***	−0.347***
	(0.080)	(0.080)	(0.076)
NOL	−0.004	−0.004	−0.001
	(0.004)	(0.004)	(0.005)
FI	−0.219***	−0.219***	−0.358***
	(0.073)	(0.073)	(0.079)
ABS_DA	−0.000	−0.000	0.003
	(0.021)	(0.021)	(0.022)
EINDEX	0.001	0.001	0.001
	(0.002)	(0.002)	(0.002)
CFO_DELTA			0.000
			(0.000)
Intercept	0.285***	0.286***	0.269***
	(0.020)	(0.020)	(0.023)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
N	7477	7477	5206
ADJ. R^2	0.076	0.076	0.102
F	7.841	7.509	7.745

$ETR_{i,t} = \beta_0 + \beta_1 NScore_{i,t-1} + \beta_2 BD\_CONN_{i,t-1} + \beta_3 SIZE_{i,t-1} + \beta_4 MB_{i,t-1} + \beta_5 ROA_{i,t-1} + \beta_6 LEV_{i,t-1} + \beta_7 PPE_{i,t-1} + \beta_8 INTAN_{i,t-1} + \beta_9 RD_{i,t-1} + \beta_{10} NOL_{i,t-1} + \beta_{11} FI_{i,t-1} + \beta_{12} ABS\_DA_{i,t-1} + \beta_{13} EINDEX_{i,t-1} + \beta_{14} CFO\_DELTA_{i,t-1} + YEAR\_FE + INDUSTRY\_FE + \epsilon_{i,t}$

See Appendix for variable definitions. Standard errors are clustered by firm. All variables except *NScore*, *BD_CONN* and *EINDEX* are winsorized at 1 and 99 percent. * indicates significance at 10 % level, ** significance at 5 %, *** significance at 1 %. Standard errors in parenthesis.

tax avoidance, we further control for board connections in the regression. We find that the coefficient on *NSscore* is still negative and significant, whereas we do not find a significant effect of board connections on tax avoidance. CFOs' risk incentives could impact their tax avoidance behavior (Rego and Wilson, 2012). In Column 3, we further control for CFO risk incentives, as measured by *CFO_DELTA*. We find that the coefficient on *NSscore* is −0.004 and significant at the 1 % level, while we do not find a significant effect of *CFO_DELTA* on tax avoidance. In sum, our results are consistent with Hypothesis 1 A that firms with more central CFOs engage more in tax avoidance.

4.2. Test for endogeneity

We provide the following arguments and evidence to support the claim that a causal relationship exists between CFO social network centrality and lower effective tax rate. First, centrality measures are lagged one year relative to the dependent variable, which at least alleviates concerns about contemporaneous endogenous effects. Second, past employment and education connections are formed in CFOs' past experience, long before they make tax decisions in the current firm. Thus, it is relatively hard to argue a reverse causality story where social connections are driven by ETRs.

To further address endogeneity concerns, we test how changes in CFO centrality affect changes in effective tax rates using the following Equations.

$$\Delta ETR_{i,t} = \beta_0 + \beta_1 \Delta NScore_{i,t-1} + \beta_2 BD\_CONN_{i,t-1} + \beta_3 SIZE_{i,t-1} + \beta_4 MB_{i,t-1} + \beta_5 ROA_{i,t-1} + \beta_6 LEV_{i,t-1} + \beta_7 PPE_{i,t-1} + \beta_8 INTAN_{i,t-1} + \beta_9 RD_{i,t-1} + \beta_{10} NOL_{i,t-1} + \beta_{11} FI_{i,t-1} + \beta_{12} ABS\_DA_{i,t-1} + \beta_{13} EINDEX_{i,t-1} + \beta_{14} CFO\_DELTA_{i,t-1} + YEAR\_FE + INDUSTRY\_FE + \epsilon_{i,t} \tag{6}$$

$$\Delta ETR_{i,t} = \beta_0 + \beta_1 NScore\_Dum_{i,t-1} + \beta_2 BD\_CONN_{i,t-1} + \beta_3 SIZE_{i,t-1} + \beta_4 MB_{i,t-1} + \beta_5 ROA_{i,t-1} + \beta_6 LEV_{i,t-1} + \beta_7 PPE_{i,t-1} + \beta_8 INTAN_{i,t-1} + \beta_9 RD_{i,t-1} + \beta_{10} NOL_{i,t-1} + \beta_{11} FI_{i,t-1} + \beta_{12} ABS\_DA_{i,t-1} + \beta_{13} EINDEX_{i,t-1} + \beta_{14} CFO\_DELTA_{i,t-1} + YEAR_{FE} + INDUSTRY_{FE} + \epsilon_{i,t} \tag{7}$$

Table 3
Endogeneity: Changes in Centrality and Changes in Tax Avoidance.

	(1) ΔETR	(2) ΔETR
ΔNScore	**−0.005***	
	(0.003)	
NScore_Dum		**−0.012****
		(0.006)
BD_CONN	−0.000	−0.000
	(0.000)	(0.000)
SIZE	−0.000	0.000
	(0.002)	(0.002)
MB	−0.032	−0.035
	(0.026)	(0.026)
ROA	0.004	0.004
	(0.017)	(0.017)
LEV	−0.006	−0.006
	(0.008)	(0.008)
PPE	−0.027**	−0.026*
	(0.014)	(0.014)
INTAN	0.086	0.091
	(0.060)	(0.060)
RD	−0.003	−0.003
	(0.004)	(0.004)
NOL	−0.124*	−0.123*
	(0.064)	(0.064)
FI	0.009	0.009
	(0.028)	(0.028)
ABS_DA	0.001	0.001
	(0.001)	(0.001)
EINDEX	0.001	0.001
	(0.001)	(0.001)
CFO_DELTA	0.001	0.001
	(0.001)	(0.001)
Intercept	0.035*	0.034
	(0.021)	(0.021)
Year FE	Yes	Yes
Industry FE	Yes	Yes
N	5414	5414
ADJ. R^2	0.002	0.002
F	2.005	2.130

$\Delta ETR_{i,t} = \beta_0 + \beta_1 \Delta NScore_{i,t-1} + \beta_2 BD\_CONN_{i,t-1} + \beta_3 SIZE_{i,t-1} + \beta_4 MB_{i,t-1} + \beta_5 ROA_{i,t-1} + \beta_6 LEV_{i,t-1} + \beta_7 PPE_{i,t-1} + \beta_8 INTAN_{i,t-1} + \beta_9 RD_{i,t-1} + \beta_{10} NOL_{i,t-1} + \beta_{11} FI_{i,t-1} + \beta_{12} ABS\_DA_{i,t-1} + \beta_{13} EINDEX_{i,t-1} + \beta_{14} CFO\_DELTA_{i,t-1} + YEAR\_FE + INDUSTRY\_FE + \epsilon_{i,t}$
$\Delta ETR_{i,t} = \beta_0 + \beta_1 NScore\_Dum_{i,t-1} + \beta_2 BD\_CONN_{i,t-1} + \beta_3 SIZE_{i,t-1} + \beta_4 MB_{i,t-1} + \beta_5 ROA_{i,t-1} + \beta_6 LEV_{i,t-1} + \beta_7 PPE_{i,t-1} + \beta_8 INTAN_{i,t-1} + \beta_9 RD_{i,t-1} + \beta_{10} NOL_{i,t-1} + \beta_{11} FI_{i,t-1} + \beta_{12} ABS\_DA_{i,t-1} + \beta_{13} EINDEX_{i,t-1} + \beta_{14} CFO\_DELTA_{i,t-1} + YEAR\_FE + INDUSTRY\_FE + \epsilon_{i,t}$
NScore_Dum is a binary variable that equals one if the *NScore* of a firm's CFO moves up at least one quintile bin from year t-1 to year t, and zero if the centrality stays in the same or moves down the quintile bins.

Table 4
Cross-sectional analysis.

	ETR			
	(1) *Percent_ID*	(2)	(3) *CFO_DELTA*	(4)
	High	Low	High	Low
NScore	−0.001	**−0.007*****	**−0.006*****	−0.002
	(0.002)	**(0.003)**	**(0.002)**	(0.003)
Difference in coefficients	0.006***		0.004*	
P-value for difference in coefficients	0.043		0.087	
Control Variables	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	2888	2318	2792	2415
ADJ. R^2	0.103	0.100	0.167	0.070
F	4.96	5.05	7.73	3.23

This table reports cross-sectional analysis on corporate governance and managerial incentives. In Columns (1) and (2), we use the percentage of independent directors (*Percent_ID*). We assign firm *i* to the better corporate governance group (*High*) when the *Percent_ID* exceeds the industry median and to the *Low* corporate governance group otherwise. In Columns (3) and (4), we use the CFO compensation delta (*CFO_DELTA*) to proxy for the managerial incentives. We assign firm *i* to the high managerial incentive group (*High*) when the *CFO_DELTA* exceeds the industry median and to the *Low* incentive group otherwise. The p-values of tests of differences in the coefficients on *NScore* are reported. See Appendix for complete variable definition. Standard errors are clustered by firm. All variables except *E*TR and *EINDEX* are winsorized at 1 and 99 percent. * indicates significance at 10 % level, ** significance at 5 %, *** significance at 1 %. Standard errors in parenthesis.

Table 5
Pairwise Connection and Tax Avoidance.

Panel A: First stage results				
	First stage	Second stage		
	(1)	(2)	(3)	(4)
	ETR	DIF_ETR	DIF_ETR	DIF_ETR
CONNECT		**−0.012****	**−0.013*****	**−0.012****
		(0.005)	**(0.005)**	**(0.005)**
SAMEIND			0.013***	0.013***
			(0.002)	(0.002)
SAMEAU			−0.001	−0.000
			(0.001)	(0.001)
SIZE	−0.002			
	(0.002)			
MB	0.002			
	(0.003)			
ROA	0.244***			
	(0.029)			
LEV	−0.051***			
	(0.017)			
PPE	−0.004			
	(0.009)			
INTAN	0.027*			
	(0.015)			
RD	−0.255***			
	(0.080)			
NOL	−0.003			
	(0.004)			
FI	−0.227***			
	(0.073)			
ABS_DA	−0.002			
	(0.021)			
EINDEX	0.001			
	(0.002)			
Intercept	0.283***	0.127***	0.126***	0.132***
	(0.020)	(0.002)	(0.002)	(0.005)
Year FE	Yes	No	No	Yes
Industry FE	Yes	No	No	No
N	7640	5751842	5751842	5751842
ADJ. R^2	0.073	0.000	0.000	0.005
F	8.350			

This table reports regression results from the two-stage gravity model.
1st Stage
$ETR_{i,t} = \beta_0 + \beta_1 SIZE_{i,t} + \beta_2 MB_{i,t} + \beta_3 ROA_{i,t} + \beta_4 LEV_{i,t} + \beta_5 PPE_{i,t} + \beta_6 INTAN_{i,t} + \beta_7 RD_{i,t} + \beta_8 NOL_{i,t} + \beta_9 FI_{i,t} + \beta_{10} ABS\_DA_{i,t} + \beta_{11} EINDEX_{i,t} + YEAR\_FE + INDUSTRY\_FE + \epsilon_{i,t}$
2nd Stage
$\ln(1 + |\epsilon_{i,t} - \epsilon_{j,t}|) = \beta_0 + \beta_1 \ln(1 + CONNECT_{i,j,t-1}) + \beta_2 \ln(1 + SAMEIND_{i,j,t}) + \beta_3 \ln(1 + SAMEAU_{i,j,t}) + YEAR\_FE + \eta_{i,j,t}$
See Appendix for complete variable definition. Standard errors are corrected for clustering of the error term at both firms levels using the double-clustering algorithm from Petersen (2008). * indicates significance at 10 % level, ** significance at 5 %, *** significance at 1 %. Standard errors in parenthesis.
First stage results are presented below as a reference. See Appendix for complete variable definition. Standard errors are clustered by firm. All variables except *ETR* and *EINDEX* are winsorized at 1 and 99 percent. * indicates significance at 10 % level, ** significance at 5 %, *** significance at 1 %. Standard errors in parenthesis.

We acknowledge that there exists firm-specific cross-sectional variation in the measurement of CFO centrality which gives rise to noise in our tests. An approach to controlling for this is to use a change model which effectively controls for firm-specific permanent differences in the valuation CFO centrality (Ittner and Larcker, 1998, Nee Ang, Pinnuck, 2011). We therefore use a change model to examine if companies change social connections will impact the change of firm tax behavior. Another benefit of using a change model is that the method has the potential to resolve the potential impact of time-invariant factors and omitted variable problems (Brown et al.,2011, Beck and Mauldin, 2014, Hu et al., 2019, Liang et al., 2023). In Eq. (6), we use Δ*NScore* to capture changes in social networks. To further capture significant changes of *NScore*, in Eq. (7), we also create a dummy variable *NScore_Dum*, which equals one if the *NScore* of a firm's CFO moves up at least one quintile bin from year t-1 to year t, and zero if the centrality stays in the same or moves down the quintile bins. The results are reported in Table 3. In Column 1, we use Δ*NScore* as the testing variable. We find that the results from the change regression are consistent with our baseline regression results. All else equal, if the CFO's centrality increases, the firm's effective tax rate decreases. In Column 2, we use *NScore_Dum* as the testing variable, and we find consistent results from the quintile change regression. [5]

5. Additional analysis

5.1. Cross-sectional analysis

In this section, we explore factors that could moderate our findings. The purpose is to enrich the insights into firms' tax avoidance and provide implications for regulators to address tax avoidance issues in firms with strong socially connected CFOs. Specifically, we explore two factors, the corporate governance effect and the managerial incentives effect. Firms with entrenched managers or weak governance are more likely to engage in tax-aggressive activities (Desai and Dharmapala, 2006, Mansi et al., 2020). Managers may have more discretion to decide whether to engage in tax avoidance behavior under less supervision. In addition, firms with greater incentive compensation help align the interests of managers and shareholders, leading managers to be more aggressive about increasing firm value through tax avoidance behavior (Armstrong et al., 2015). In order to test these two moderating effects, we partition the sample based on whether the proxies exceeding the industry median for all such firms in each year. We expect to find weak corporate governance firms engage in more tax avoidance when the CFO centrality increases, and firms with greater CFO incentive compensation have more tax avoidance behavior.

We report Table 4 to provide empirical evidence on our arguments. In Table 4 Column (1) and (2), we use the percentage of independent directors (*Percent_ID*). We assign firm *i* to the better corporate governance group (*High*) when the *Percent_ID* exceeds the industry median and to the *Low* corporate governance group otherwise. As shown in Columns (1) and (2), the coefficient on *NScore* for the weak corporate governance group is negatively significant at the 1 % level, while the coefficient for the strong corporate governance group is insignificant. In Columns (3) and (4), we use the CFO compensation delta (*CFO_DELTA*) to proxy for the managerial incentives. We assign firm *i* to the high managerial incentive group (*High*) when the *CFO_DELTA* exceeds the industry median and to the *Low* incentive group otherwise. As shown in Columns (3) and (4), the coefficient on *NScore* for the high manager's incentives group is negatively significant at the 1 % level, while the coefficient for

[5] One may concern on the magnitude of adjusted R^2 we reported. To gauge the potential omitted variable problem, we follow Oster (2019) to recover the bounds for "true" β coefficients using two parameter values (i.e., R^2 and δ) derived from a simulation. The "true" β is likely bounded at [-0.008, −0.004] with 1.3 R^2 and $\delta = 1$. With such a bound in mind, Oster (2019) proposes two ways for assessing the robustness of estimated β coefficients: whether the bound (1) falls within the 99.5 % confidence interval for the coefficient, and (2) excludes zero. Because the (1) likely bounds for β [−0.348, −0.223] fall within the 99.5 % confidence interval for β in our main regression table, and (2) the bounding estimate excludes zero, the estimated β coefficient in our main regression is not likely driven by unobservable shocks that are at least as important as the observable, controlled covariates. We get $\delta = 2.794$ from Eq. (5)= 0, suggesting that unobservable social connection factors must be more than twice as important as observable, controlled factors to produce no treatment effect (i.e., β= 0). Given that Eq. (5) already controls for several social connection factors and industry-year fixed effects, it is unlikely that such unobservable factors drive our main results.

Table 6
Who Is Following Whom – Evidence from Simultaneous Equations.

	(1) ETR Non-central	(2) ETR Central
Lag_ETR Central	**0.290****	**0.463*****
	(0.135)	**(0.098)**
Lag_ETR Non-central	−0.055	0.013
	(0.091)	(0.066)
Lag2_ETR Non-central	0.046	
	(0.108)	
Lag2_ETR Central		0.086
		(0.079)
SAMEIND	0.020	0.031
	(0.045)	(0.033)
SAMEAU	0.031	0.019
	(0.033)	(0.023)
SIZE	−0.007	(0.079)
	(0.010)	0.003
MB	−0.015	0.014*
	(0.015)	(0.008)
ROA	0.433**	(0.009)
	(0.168)	0.077
LEV	−0.150	(0.093)
	(0.108)	−0.025
PPE	0.063	(0.072)
	(0.050)	0.037
INTAN	0.151*	(0.037)
	(0.079)	−0.017
RD	0.135	(0.054)
	(0.514)	−0.439**
NOL	0.017	(0.198)
	(0.026)	0.014
FI	−0.882**	(0.018)
	(0.420)	0.102
ABS_DA	0.117	(0.234)
	(0.152)	−0.131
EINDEX	−0.010	(0.140)
	(0.009)	−0.009
CFO_DELTA	0.000	(0.006)
	(0.000)	−0.000
Intercept	0.013***	0.007***
	(0.002)	(0.001)

This table reports regression results from the following structural model of granger causality tests.
$ETR_{i,t} = \beta_{10} + \beta_{11}ETR_{j,t-1} + \beta_{12}ETR_{i,t-1} + \beta_{13}ETR_{i,t-2} + \beta_{14}SAMEIND_{i,j,t-1} + \beta_{15}SAMEAU_{i,j,t-1} + Controls_{i,t-1} + \epsilon_{i,t}$
$ETR_{j,t} = \beta_{20} + \beta_{21}ETR_{j,t-1} + \beta_{22}ETR_{j,t-1} + \beta_{23}ETR_{j,t-2} + \beta_{24}SAMEIND_{i,j,t-1} + \beta_{25}SAMEAU_{i,j,t-1} + Controls_{j,t-1} + \epsilon_{j,t}$
For each pair firm, the firm that is more central is denoted by i, and similarly the firm that is less central is denoted by j. *SAMEAU* is and indicator variable that takes a value of one if two firms are audited by the same auditor that year, and zero otherwise. *SAMEIND* is an indicator variable that takes a value of one if two firms belong to the same two-digit SIC code industry for the year, and zero otherwise. See Appendix for complete variable definition. All variables except ETR , *EINDEX*, and indicator variables are winsorized at 1 and 99 percent. * indicates significance at 10 % level, ** significance at 5 %, *** significance at 1 %. Standard errors in parenthesis.

the low incentives group is insignificant. Table 4 shows that the effect of CFO social connection is more pronounced in the weak corporate governance firms and those with greater incentive compensation. These results suggest that CFO social connection could intensify tax avoidance when corporate governance is weaker and manager's incentive is higher.

5.2. Information exchange channel: pairwise model

If the relation between CFO centrality and ETR is driven by the information advantage of central CFOs derived from CFO social networks rather than by CFO-specific characteristics, we should expect firm pairs whose CFOs are connected to each other to have similar effective tax rates. To test Hypothesis 2, we estimate a two-stage gravity model. Gravity models are used when outcomes are affected by the distance between objects, like gravity. In economics, gravity models have been used in international trade to explain bilateral trade flows between two countries (e.g., Frankel and Romer, 1999). In a similar setting to our paper, Fracassi (2017) uses a gravity model to test the impact of social connections on the similarity of corporate investment policies. Therefore, the gravity model is ideal for testing Hypothesis 2 as we want to examine how similar the degrees of tax avoidance are between two connected firms compared to two unconnected firms. Following Fracassi (2017), we use the following equations to test the two-stage gravity model.

1st Stage

$$\begin{aligned} ETR_{i,t} = {} & \beta_0 + \beta_1 SIZE_{i,t} + \beta_2 MB_{i,t} + \beta_3 ROA_{i,t} + \beta_4 LEV_{i,t} + \beta_5 PPE_{i,t} \\ & + \beta_6 INTAN_{i,t} + \beta_7 RD_{i,t} + \beta_8 NOL_{i,t} + \beta_9 FI_{i,t} \\ & + \beta_{10} ABS\_DA_{i,t} + \beta_{11} EINDEX_{i,t} + YEAR\ FE + INDUSTRY\ FE + \epsilon_{i,t} \end{aligned} \tag{8}$$

2nd Stage

$$\begin{aligned} \ln(1 + |\epsilon_{i,t} - \epsilon_{j,t}|) = {} & \beta_0 + \beta_1 \ln(1 + CONNECT_{i,j,t-1}) + \beta_2 \ln(1 + SAMEIND_{i,j,t}) \\ & + \beta_3 \ln(1 + SAMEAU_{i,j,t}) + YEAR\ FE + \eta_{i,j,t} \end{aligned} \tag{9}$$

In the first stage, ETR is regressed over the control variables discussed in the baseline regress previously. We report the results of the first stage regressions in Table 5 Column 1. The residual $\epsilon_{i,t}$ of the regression measures the idiosyncratic component of ETR of company i at time t, relative to the expected ETR according to the standard model. For

Table 7
Social Network of CEO and Top Executive Team.

	(1) ETR	(2) ETR
*CEOtie_*	**−0.041****	
	(0.019)	
EXEtie		**−0.037****
		(0.015)
SIZE	0.005	0.006*
	(0.003)	(0.004)
MB	0.002	0.000
	(0.004)	(0.004)
ROA	0.234***	0.242***
	(0.053)	(0.054)
LEV	−0.057**	−0.055**
	(0.024)	(0.024)
PPE	0.004	0.004
	(0.014)	(0.014)
INTAN	0.014	0.014
	(0.022)	(0.022)
RD	−0.467***	−0.431***
	(0.093)	(0.096)
NOL	−0.005	−0.005
	(0.006)	(0.006)
FI	−0.442***	−0.422***
	(0.106)	(0.108)
ABS_DA	−0.015	−0.017
	(0.030)	(0.031)
EINDEX	0.001	0.001
	(0.002)	(0.002)
CFO_DELTA	0.000	0.000
	(0.000)	(0.000)
Intercept	0.237***	0.230***
	(0.034)	(0.035)
Year FE	Yes	Yes
Industry FE	Yes	Yes
N	2707	2707
ADJ. R^2	0.124	0.125
F	6.428	6.271

CEOtie and *EXEtie* are scaled by 100. Standard errors are clustered by firm. All variables except *ETR* and *EINDEX* are winsorized at 1 and 99 percent. * indicates significance at 10 % level, ** significance at 5 %, *** significance at 1 %. Standard errors in parenthesis.

each pair of companies i and j, we take the absolute value of the difference in their residual $|\epsilon_{i,t} - \epsilon_{j,t}|$. This variable is a proxy for the difference in tax avoidance strategies between the two companies.

In the second stage, a gravity model tests how social ties influence similarity in tax avoidance. We thus proceed to take the natural logarithm of the difference in residual $|\epsilon_{i,t} - \epsilon_{j,t}|$ and regress it over the lagged natural logarithm of *CONNECT*, which is a binary variable indicating the existence of a link between the two CFOs. Firms in the same industry or have the same auditor might have similar tax avoidance behavior. To rule out these effects, we also control for the same industry and the same auditor in the model. *SAMEIND* is an indicator variable that takes a value of one if two firms belong to the same two-digit SIC code industry for the year. *SAMEAU* is an indicator variable that takes a value of one if two firms are audited by the same auditor in that year and zero otherwise. When estimating the second-stage equation, we account for serial correlation by allowing for clustering of the error term at the firm level for both i and j using the double-clustering algorithm from Cameron et al. (2008) and Petersen (2008).

Table 5 further reports the results from the second stage of the gravity model. Consistent with our prediction, the coefficients on *CONNECT* are consistently and significantly negative. All else equal, firms have similar ETRs if their CFOs are socially connected. The effect is also economically significant: two firms that are socially connected have an effective tax that is more similar by 1.2 % of taxable income relative to companies that are not socially connected. To put this in perspective, the median difference in effective tax between two companies is 9.1 % of taxable income, so social ties reduce the tax gap by approximately 13.2 %.

5.3. Power channel: who is following whom?

We argue that central firms have more power, more influence, and fewer constraints to engage in tax avoidance behavior because their network positions give them more resources and alternative opportunities. To test this conjecture, we use a granger causality test to examine whether non-central CFOs follow the tax strategies of central CFOs or vice versa. Specifically, we estimate the following simultaneous equation system.

$$\begin{aligned} ETR_{i,t} &= \beta_{10} + \beta_{11}ETR_{j,t-1} + \beta_{12}ETR_{i,t-1} + \beta_{13}ETR_{i,t-2} + \beta_{14}SAMEIND_{i,j,t-1} \\ &\quad + \beta_{15}SAMEAU_{i,j,t-1} + Controls_{i,t-1} + \epsilon_{i,t} \\ ETR_{j,t} &= \beta_{20} + \beta_{21}ETR_{j,t-1} + \beta_{22}ETR_{j,t-1} + \beta_{23}ETR_{j,t-2} + \beta_{24}SAMEIND_{i,j,t-1} \\ &\quad + \beta_{25}SAMEAU_{i,j,t-1} + Controls_{j,t-1} + \epsilon_{j,t} \end{aligned} \tag{10}$$

The sample is restricted to firms with at least one social connection. For each pair of firms that are connected through CFOs, the firm with higher CFO centrality is denoted by i, and the firm with lower CFO centrality is denoted by j. The ETR of each firm is regressed on the lagged ETR of the connected firm as well as the lagged ETR of the firm itself. In addition to that, the following control variables are included. *SAMEAU* is an indicator variable that takes a value of one if two firms are audited by the same auditor that year, and zero otherwise. *SAMEIND* is an indicator variable that takes a value of one if two firms belong to the same two-digit SIC code industry for the year, and zero otherwise. Controls in the baseline regression are also included for the firm on the left-hand side.

The results are reported in Table 6. We find that the ETRs of firms with non-central CFOs are predicted by the lagged ETRs of their central CFO connections at the significant level of 5 %. On the other hand, the ETRs of central CFOs are not predicted by the ETRs of their non-central CFO connections, but by their own lagged ETRs at the significance level of 1 %. The results suggest that non-central CFOs follow the tax strategies of central CFOs, but not the other way around. The results provide some supportive evidence for our power channel.

5.4. CEOs and other top executives

In addition to CFOs, CEOs and other executives' social networks could also be important for corporate tax avoidance strategies. To test this prediction, we perform the same tests using the social networks of top executives combined with social networks of CEOs and report the results in Table 7. Consistent with the results from CFO networks, we find that higher centrality of the top executives is also associated with lower ETR; more CEO social connections are also associated with lower ETR. The results indicate that beyond CFOs, CEOs and other executives' social networks also negatively affect corporate tax avoidance.

5.5. Alternative measures of CFO network centrality

Our social network measure, *NSscore*, is an aggregated level measure based on different dimensions of social networks. To examine how individual dimensions of social networks affect tax avoidance, we use *DEGREE*, *BETWEENNESS*, *CLOSENESS*, and *EIGENVECTOR*, and their normalized measures as alternative measures of centrality. Table 8 reports results for the baseline model using these alternative individual centrality measures. We find that for *DEGREE*, *BETWEENNESS*, and *CLOSENESS*, all six coefficients on these individual centrality measures are significantly negative, confirming a negative relation between CFO social networks and tax avoidance. However, we do not find a significant result when we use *EIGENVECTOR* as the individual measure of centrality.

Table 8
Sensitivity Analysis – Alternative Measure of Network Centrality.

	(1) ETR	(2) ETR	(3) ETR	(4) ETR	(5) ETR	(6) ETR	(7) ETR	(8) ETR
DEG_NOR	**−2.832***** **(0.931)**							
DEG		**−0.002***** **(0.001)**						
BET_NOR			**−2.235**** **(0.870)**					
BET				**−0.000**** **(0.000)**				
CLO_NOR					**−17.701**** **(6.999)**			
CLOSENESS						**−17543.684**** **(8177.448)**		
EIG_NOR							**0.034** **(0.063)**	
EIG								**0.011** **(0.023)**
BD_CONN	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)
SIZE	0.001 (0.002)	0.001 (0.002)	−0.000 (0.002)	−0.000 (0.002)	0.001 (0.002)	0.000 (0.002)	−0.001 (0.002)	−0.001 (0.002)
MB	0.000 (0.003)	0.000 (0.003)	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)
ROA	0.254*** (0.040)	0.254*** (0.040)	0.257*** (0.040)	0.256*** (0.040)	0.251*** (0.040)	0.252*** (0.040)	0.255*** (0.040)	0.255*** (0.040)
LEV	−0.066*** (0.019)	−0.066*** (0.019)	−0.067*** (0.019)	−0.067*** (0.019)	−0.066*** (0.019)	−0.066*** (0.019)	−0.067*** (0.019)	−0.067*** (0.019)
PPE	0.002 (0.012)	0.002 (0.012)	0.002 (0.012)	0.002 (0.012)	0.002 (0.012)	0.002 (0.012)	0.002 (0.012)	0.002 (0.012)
INTAN	0.032* (0.018)	0.032* (0.018)	0.033* (0.018)	0.033* (0.018)	0.032* (0.018)	0.031* (0.018)	0.032* (0.018)	0.032* (0.018)
RD	−0.348*** (0.076)	−0.347*** (0.076)	−0.348*** (0.076)	−0.348*** (0.076)	−0.345*** (0.076)	−0.346*** (0.076)	−0.351*** (0.076)	−0.352*** (0.076)
NOL	−0.002 (0.005)	−0.001 (0.005)	−0.002 (0.005)	−0.002 (0.005)	−0.002 (0.005)	−0.002 (0.005)	−0.002 (0.005)	−0.002 (0.005)
FI	−0.364*** (0.079)	−0.361*** (0.079)	−0.357*** (0.079)	−0.355*** (0.079)	−0.358*** (0.079)	−0.359*** (0.079)	−0.357*** (0.079)	−0.357*** (0.079)
ABS_DA	0.003 (0.022)	0.002 (0.022)	0.002 (0.022)	0.002 (0.022)	0.003 (0.022)	0.003 (0.022)	0.002 (0.022)	0.002 (0.022)
EINDEX	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)
CFO_DELTA	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Intercept	0.260*** (0.024)	0.261*** (0.023)	0.266*** (0.023)	0.267*** (0.023)	0.263*** (0.023)	0.264*** (0.023)	0.268*** (0.023)	0.268*** (0.023)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	5206	5206	5206	5206	5206	5206	5206	5206
ADJ. R^2	0.102	0.102	0.101	0.101	0.102	0.101	0.100	0.100
F	7.841	7.801	7.877	7.832	7.793	7.810	7.799	7.792

See Appendix for complete variable definition. Standard errors are clustered by firm. All variables except *E*TR and *EINDEX* are winsorized at 1 and 99 percent. * indicates significance at 10 % level, ** significance at 5 %, *** significance at 1 %. Standard errors in parenthesis.

Table 9
Controlling for CFO-Auditor connections.

	(1) ETR	(2) ETR
NScore	**−0.003***	**−0.004****
	(0.002)	**(0.002)**
BD_CONN	−0.000	−0.000
	(0.000)	(0.000)
CFO_Au	−0.016	−0.016
	(0.011)	(0.012)
SIZE	−0.001	0.001
	(0.002)	(0.002)
MB	0.001	0.000
	(0.003)	(0.003)
ROA	0.228***	0.252***
	(0.036)	(0.040)
LEV	−0.054***	−0.066***
	(0.017)	(0.019)
PPE	−0.003	0.002
	(0.010)	(0.012)
INTAN	0.031**	0.033*
	(0.016)	(0.018)
RD	−0.265***	−0.347***
	(0.080)	(0.076)
NOL	−0.004	−0.001
	(0.004)	(0.005)
FI	−0.222***	−0.362***
	(0.073)	(0.079)
ABS_DA	−0.001	0.002
	(0.021)	(0.022)
EINDEX	0.001	0.001
	(0.002)	(0.002)
CFO_DELTA		0.000
		(0.000)
Intercept	0.331***	0.319***
	(0.017)	(0.020)
Year FE	Yes	Yes
Industry FE	Yes	Yes
N	7477	5206
ADJ. R^2	0.076	0.102
F	7.329	7.527

CFO_Au is a binary variable that equals one if the CFO of a firm has at least one connection with the auditing firm, and zero otherwise. See Appendix for complete variable definition. Standard errors are clustered by firm. * indicates significance at 10 % level, ** significance at 5 %, *** significance at 1 %. Standard errors in parenthesis.

5.6. Controlling for CFO-Auditor Connections

A possible endogeneity concern arises from the omitted variable that could drive both social networks and tax avoidance. For example, Bratten et al. (2019) find that a long-term relationship between firms and auditors positively affects financial reporting quality. Thus, central CFOs might have connections with auditors as well, and the latter might allow them to be subjected to lenient scrutiny and therefore have more room to manage taxes. We include a dummy variable *CFO_Au* that equals one if the CFO of a firm has at least one connection with the auditing firm, and zero otherwise. The results are reported in Table 9. We find that the coefficients on *NScore* remain negative and significant. Therefore, our findings sustain after controlling for the CFO-Auditor connections.

6. Conclusion

Motived by the emerging literature on social networks in accounting and finance, we examine whether CFOs' social networks affect corporate tax behavior. By constructing the comprehensive CFO social networks of U.S. companies that arise from employment, education, and other activities, we find that firms with CFOs that occupy more central positions in the network have lower effective tax rates. Moreover, the effective tax rate of a firm decreases if the CFO centrality of the firm increases.

Examining potential explanations for this empirical pattern, we find that firms have similar ETRs if their CFO's are socially connected. These findings suggest that information on a range of tax avoidance strategies is shared among firms through CFOs' social network connections, and as a consequence, centrally located CFOs derive an information advantage over others on tax avoidance strategies because they are exposed to more information. In addition, the past ETRs of central CFOs predict the ETRs of non-central CFOs that they are socially connected with. This finding suggests that central CFOs are more powerful and influential, whereas non-central CFOs follow central CFOs for tax planning. Overall, our findings suggest that socially better-connected CFOs have more information and resources to adopt aggressive tax strategies than less-connected CFOs.

This paper introduces social network theory into the tax avoidance literature. It enhances our understanding of the determinants of tax avoidance and responds to the call by Hanlon and Heitzman (2010) to examine how social networks influence corporate tax avoidance. This paper also complements our understanding of how executives' social networks influence corporate decision-making. Finally, we acknowledge that, due to the nature of both social networks and tax avoidance, our findings may be subject to endogeneity concerns. It is also important to note that firm centrality differs from CFO centrality. Future research could explore how firm centrality influences corporate decision-making, including tax decisions.

CRediT authorship contribution statement

Zhou Zejiang: Writing – review & editing, Supervision, Resources, Investigation. **Wu Qiang:** Writing – review & editing, Supervision, Resources, Conceptualization. **Xu Xin (Emma):** Writing – review & editing, Visualization, Methodology, Investigation. **Fang Ming:** Writing – original draft, Formal analysis, Data curation.

Appendix

Variable Definitions

Variable	Definition
Tax Avoidance Measures	
ETR	Effective tax rate. (ETR) is defined as total income tax expense (TXT) divided by pre-tax book income (PI) before special items (SPI). $ETR_{i,t}$ is set as missing when the denominator is zero or negative. We truncate ETRi,t to the range [0,1].
Social Network Measures	
NScore	Combined centrality measure defined by $NScore = \frac{Quint(DEG) + Quint(BET) + Quint(CLOSENESS) + Quint(EIG)}{4}$

(continued on next page)

(*continued*)

Variable	Definition
DEGREE	Degree is the sum of all links that a firm has with other companies in the network. The normalized degree CD(x), of a node x is the sum of all links that a firm has with other companies in the network divided by the number of companies in the network.
BET	Betweenness of a firm is the sum of probabilities across all possible company pairs that the shortest path between the two companies passes through the firm. It measures a node's ability to act as an intermediary, bringing other nodes together. The absolute betweenness of a node *x is defined by*
	$C_B(x) = \sum_{y<z} \frac{m(y,z;x)}{m(y,z)}$ where *m(y, z; x) is the number of shortest paths between y and z through unit x, and m(y, z) is the number of shortest paths between y and z.*
CLOSENESS	Closeness of a firm is the inverse of the sum of graph theoretic distances to all other companies from the firm. It indicates a node's ability to quickly interact with all others on the network. The absolute closeness of a node x is defined by
	$C_C(x) = \frac{1}{\sum_{y\in U} d(x,y)}$ where *U represents the set of all nodes on the network, and d(x, y) is the number of edges in a shortest path connecting units x and y.*
EIG	Eigenvector is a measure of the influence of a node in a network. It assigns relative scores to all nodes in the network based on the concept that connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes. The centrality score of node x can be defined as
	$C_E(x) = \frac{1}{\lambda}\sum_{y\in U} a_{x,y} C_E(y)$ (3)where U represents the set of all nodes on the network,
	λ is a constant, and $a_{x,y} = 1$ if node x is linked to node y, and 0 otherwise. With a small rearrangement this can be rewritten in vector notation as the eigenvector equation $Ax = \lambda x$.
CONNECT	CONNECT is a binary variable that takes a value of one if two firm's CFOs are socially connected with each other, and 0 otherwise.
BD_CONN	Board connectivity measured by degree centrality.
Control Variables	
SAMEAU	An indicator variable that takes a value of one if two firms are audited by the same auditor in that year and zero otherwise.
SAMEIND	An indicator variable that takes a value of one if two firms belong to the same two-digit SIC code industry for the year.
SIZE	The natural log of market value of equity (MKVAL).
MB	Market to book ratio.
ROA	The sum of earnings before tax and special items (PI-SPI), divided by lagged total assets (AT).
LEV	Total long-term debt (DLTT), scaled by total assets (AT). We set missing observations of DLTT equal to zero.
PPE	Total net property, plant and equipment (PPEGT), scaled by total assets (AT).
INTAN	Total intangible assets (INTAN), scaled by total assets (AT).
RD	Research and development expense (XRD) scaled by total assets (AT). Missing values in XRD are set to zero.
NOL	A dummy variable coded as one if loss carry forward (TLCF) is positive at the beginning of the year.
FI	Foreign income (PIFO) scaled by lagged total assets (AT), Missing values in PIFO are set to zero.
ABS_DA	Absolute value of discretionary accruals, where discretionary accruals are computed using the modified Jones model including lagged ROA as an additional regressor.
EINDEX	Entrenchment Index.
CFO_DELTA	Delta of CFO compensation.

Data availability

Data will be made available on request.

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