Help or Hindrance? Boardroom Network Connectivity and Firm Performance

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Abstract

While boardroom networks should act as a conduit for resource sharing between firms, and in doing so improve firm performance, recent evidence on the value of connected boards is limited and inconclusive. This study aims to provide additional evidence on the impact of board connectivity on firm performance by exploring Australian listed firms between 2001 and 2011. We employ four dimensions of connectivity; measuring the quantity, speed and quality of information flow and resource sharing, and a firms access to the best-connected boards. We also employ a factor of the four connectivity dimensions. Our findings show more connected boards have lower firm performance, measured with Tobin's Q. The results remain consistent after controlling for alternative measures of firm performance, and model specifications. The results suggest that boardroom networks are not a value-enhancing tool for boards.

Keywords: Corporate Governance, Resource Dependence, Board of Directors, Social Networks, Centrality

JEL Codes: C33, G32, G34

1. Introduction

The prevailing literature has identified two primary roles for the board of directors; an agency role monitoring management, and as a provider of “human capital” resources. While much of the finance literature has focused on directors providing oversight for managers (Baysinger & Butler, 1985; Fama, 1980), resource dependency theory, based heavily in the management literature, contends that directors play a role in assisting managers by providing advice and counsel, and access to additional expertise and connections (Hillman & Dalziel, 2003; Pfeffer & Salancik, 1978). Resource dependence theory therefore argues that board capital attributes, such as skills, experiences, knowledge and connections, should add value to the firm.

One aspect of board capital that is yet to be fully examined is the role of board connectivity. Due to the extensive skillset directors require, the pool of qualified directors is limited. As a result, directors often appear on multiple boards, creating interlocks. Prior literature has established that interlocking boards facilitate flows of information, such as sharing experiences and mistakes (Davis, 1991; Haunschild, 1993), and can create beneficial relationships (Dooley, 1969; Houston et al., 2014), allow firms to trade favours (Engelberg et al., 2012) and negotiate better contractual arrangements (Mizruchi, 1996). However, interlocks may also result in firms circulating value-decreasing corporate practices (Bizjak et al., 2009), replicating mistakes (Mizruchi, 1996), may weaken monitoring (Fich & White, 2003) and, could result in cartel behaviour, price collusion and reduced competition (Mizruchi, 1996). Additionally, firms may become overwhelmed with too much information (Chewning & Harrell, 1990; O'Reilly, 1980).

Studies looking at the impact of interlocks on firm performance generally find either no impact (Kiel and Nicholson, 2006) or a negative effect (Non & Franses, 2007; Santos et al., 2009). More recently studies have started to employ social network theory to explore board connections in a wider context. Social network theory argues that interlocking boards create a wider network of firms, allowing the flow of resources and information between distant firms through intermediary firms (Wasserman & Faust, 1994) which the interlocking literature fails to consider. Firms in a larger network and those well positioned in terms of access to information should have access to more resources through the network (Hillman & Dalziel, 2003; Horton et al., 2012; Wasserman & Faust, 1994). However, while theory suggests that well-connected firms should benefit more, the empirical evidence to date is mixed. Some studies find a positive association between board connectivity and firm performance (Horton et al., 2012; Larcker et al., 2013), while others find a negative impact (Andres et al., 2013; Omer et al., 2013).

This study examines the effect of social network measures of board connectivity on firm performance in Australia. We use a sample of firms listed on the Australian Securities Exchange (ASX) between 2001 and 2011, resulting in 10,599 firm-year observations. We employ four measures of board connectivity drawn from the social network theory; *Degree, Closeness*, *Betweenness* and *Eigenvector*, which measure different aspects of firm connectivity. In addition, we employ principle component analysis (PCA) to derive a connectivity factor. Using regression analysis, we test the network connectivity measures against firm performance defined as Tobin's Q, although we additionally test the impact of connectivity on return on assets and total stock returns. Additionally, we consider both a contemporaneous relationship, and firm performance one-year ahead of connectivity and employ both pooled OLS and firm fixed effects with lagged dependent variables to control for potential endogeneity.

After controlling for other factors that may influence the relationship, we observe a negative relationship between connectivity and firm performance, consistent with Omer et al. (2013) and Andres et al. (2013). Irrespective of the connectivity measure employed, board connectivity detrimentally impacts on firm performance. Additionally, the connectivity factor, created using PCA, also shows board connectivity harms firm performance. The findings remain broadly consistent despite employing alternative firm performance measures and using alternative model specifications. Additionally, we test for potential reverse causality and find that rather than changes in connectedness driving changes in firm performance, it is firm performance that drives changes in the level of connectedness. Specifically, an increase in Tobin's Q is associated with a subsequent increase in *Eigenvector*. The results show that more connected boards negatively impact on firm performance. Several possible explanations have been offered for this including firms receiving too much information to be efficiently processed, the introduction of value decreasing corporate practices or undermining board monitoring.

The remainder of this paper is structured as follows: Section 2 provides a discussion on the related board network literature commencing with evidence on interlocks and the resulting network flow, followed by board connectivity. Section 3 outlines the data, methodology and sample statistics, including a comprehensive description of the network measures employed. Section 4 presents a discussion of the empirical results, beginning with the main findings followed by robustness tests. Section 5 concludes the paper.

2. Literature Review and hypotheses development

2.1 The Role of the Board of Directors

While much of the finance literature has focused on the boards monitoring role, there is a growing focus on the broader role that boards have in the operating and strategic direction of the company (Hillman et al., 2009; Masulis et al., 2012). Directors are selected for the considerable skills, knowledge and expertise they bring to the role, which makes for a relatively limited pool of qualified individuals. As a result, board members may hold multiple directorships, creating interlocks between the boards of those companies. Directors holding multiple board seats also opens up access to a wider pool of experiences, knowledge and connections which may add additional value to the firm.

An increasing body of literature examines interlocking relationships between firms. Board interlocks establish networks between firms that allow for the spread of information (Wasserman & Faust, 1994) allowing for firms to learn from others. For instance, Haunschild (1993) finds that interlocking boards are more likely to mimic the recent acquisition activities of the firms they are connected to. Further, Davis (1991) finds that the more ties a firm has to those that have adopted a poison pill clause, the more likely they are to adopt the practice themselves. As well as imitating corporate strategies, interlocked directors may also pass on the experiences and mistakes made by other firms (Mizruchi, 1996). CEO's interviewed in Useem (1984) contend that seats on other boards provide private information that executives can use within their own firm.

Additionally, multiple directorships also help to facilitate beneficial business relationships. Studies have found that firms connected to the banking and financial sector (Engelberg et al., 2012) or with political connections (Houston et al., 2014) have lower interest rates with fewer debt covenants, which improves shareholder value. Interlocks also assist with contract negotiations, as the social rapport between directors may result in quid-pro-quo behaviour (Mizruchi, 1996) and improve negotiations with suppliers of key inputs (Schoorman et al., 1981).

While the above benefits have been documented, other studies have identified issues with interlocks. For instance, interlocking boards may result in spreading value-decreasing corporate practices. For example, stock options backdating is common in firms with interlocking boards (Bizjak et al., 2009). Likewise, shared knowledge may also result in firms replicating mistakes in operating procedures or strategic decisions (Mizruchi, 1996), or imitating activities that give them a bad name, such as earnings management (Chiu et al., 2012). It may also be that interlocks undermines corporate governance. Fich and White (2003), for instance, find CEO pay tends to be higher and CEO turnover lower when the boards are "mutually interlocked".[1] Additionally, firms may engage in cartel behaviour, colluding on price and reducing competition, raising significant legal hazards which can severely reduce the value of the firm if discovered (Mizruchi, 1996).

Another issue that can arise is directors who hold too many board seats. Directors with a lot of directorships may be unproductive due to higher stress levels and limitations on the time a director can expend on each firm. This is referred to as "busyness"[2] and has been shown to result in reduced monitoring and firm performance (Fich & Shivdasani, 2006).

[1] Mutually interlocked is defined as when a board has at least *two* directors who are also members of another firms board (Fich & White, 2003).
[2] "Busyness" is referred to by Fich and Shivdasani (2006) as an outside director who holds three or more directorships.

Additionally, highly connected boards may receive too much information. Unless firms are able to efficiently process the information they receive, the firms risk being overloaded (Swain & Haka, 2000), distorting a firm's ability to make good decisions regarding their forthcoming plans (Chewning & Harrell, 1990; O'Reilly, 1980).

2.1.1 Connectivity and Firm Performance

Recently, studies have begun to focus on the economic outcomes of corporate ties, finding a generally negative relationship between interlocks and firm performance. For instance, Kiel & Nicholson (2006) investigate the impact of interlocks on stock returns in Australia and find no significant relationship. Non and Franses (2007) examine a sample of 101 large firms in the Netherlands between 1994 and 2004 and find that interlocks have a small negative effect on firm performance. Santos, Da Silveira, and Barros (2009) study the Brazilian market using a sample of firms for three years, 2001, 2003, and 2005, and find that Tobin's Q is negatively impacted by board interlocks. They do find however, that a small number of interlocks is beneficial with the optimal number at around five connections. One issue with these studies is that they are primarily focused just on the direct connections between firms, and so fail to consider other dimensions of connectedness.

Social network theory argues that if Firm A is directly connected Firm B, it is by extension also indirectly connected to each of the others firms that are directly connected to Firm B, establishing a broad network of firms. This allows for estimating and measuring a number of additional dimensions of connectivity which may impact firm value. The four measures commonly used in the social network literature are *Degree*, *Closeness*, *Betweenness* and *Eigenvector*. *Degree* measures the direct connections a firm has, essentially the number of interlocks, and proxies for the direct access to information a firm has. In contrast, *Closeness*, *Betweenness* and *Eigenvector* measure the indirect connections of a firm. *Closeness* estimates how central a board is within a network by looking at the distance between the firm and the rest of the firms in the network, measured by the shortest number of connections between two firms. More central firms have better quality and faster access to information. *Betweenness* measures the intermediate connections a board has, defined as being between two other firms. Intermediately linked firms act as conduits for information and resources between indirectly connected firms, giving the intermediary firm access or the ability to control the flow of this information and resources. *Eigenvector* measures the extent to which a firm is connected to highly connected companies by considering both the number and connectivity of its connections. In our setting, a higher *Eigenvector* measure indicates better access to information and resources from highly connected boards.

The different dimensions of connectivity capture distinct yet interrelated aspects of a firm's connections and collectively demonstrate a firms overall position in the corporate network. To accurately estimate the impact of connectivity on firm performance, it is important to consider connectivity within a broader context.

2.1.2 Board Connectivity

To date, few studies have empirically investigated the effect of board connectivity on firm performance. Hochberg et al. (2007) were the first to apply social network measures within the finance context, finding that better connected venture capital firms have significantly better fund performance. Horton et al. (2012) also finds that better connected firms have improved firm performance, based on total stock returns, market to book ratios and return on assets, for London Stock Exchange listed firms. They also find that well-connected directors are compensated for the benefits that their better connections are perceived as providing. Larcker et al. (2013) examines a composite score based on the four connectivity measures in the US for both public and private companies. They find that more central (connected) firms earn superior characteristic-adjusted returns and have higher future growth in return on assets. Their findings are stronger for growth firms, and firms facing adverse circumstances which implies that these types of firms benefit most from board connectivity.

In contrast, Omer et al. (2013) examines firms in the US and find that the impact on return on assets and Tobin's Q depends on the connectivity measure, a positive relationship with *Degree* but negative relationships with *Closeness* and *Eigenvector*. Along similar lines, Andres et al. (2013) finds that German companies with well-connected boards (Degree and Eigenvector) perform worse. The authors also argue that the negative effect is driven by board connections undermining the monitoring role of directors. Given the conflicting evidence on the impact of board connectivity and firm performance, the value of well-connected boards remains an open question. It is also intriguing that while well connected directors appear to be paid for their connections, yet it is not clear that those connections are value enhancing.

3. Methodology and Data

3.1 Network Construction and Measures

The linkages formed by directors sitting on multiple boards create more complex networks where boards can act as intermediaries between unconnected firms. These wider networks can be viewed within the framework of social network theory. An example of a simple board network is presented in Figure 1. Within this example, Firm 5 has board members sitting on the other four companies' boards and occupies the most central position in the network in terms of direct connections. Firm 5 also represents an intermediary for information flows between firms not directly connected, such as Firms 4 and 2. We employ four commonly used social network measures that measure different aspects of a firm's position and centrality within the network. The first measure we employ is the number of direct connections a firm has, referred to as *Degree* in Freeman (1979), and which is a very similar measure to board interlocks as applied in previous studies (e.g. Non & Frances, 2007). *Degree* is defined as the number of unique direct connections between the board members of Firm *i* and all other firms, i.e.

$$C_{i,\tau}^{D} = \sum_{j=1}^{n-1} \delta(i,j)\,, \quad j \neq i \qquad (1)$$

Where *δ(i,j)* is a dummy variable that equals one if there is at least one director in common between Firms *i* and *j* and zero otherwise.[3] *Degree* measures a firm's direct access to information. A higher *Degree* score indicates a firm with more connections, and by extension more opportunities for the firm to exchange or acquire information (Freeman, 1979). To take into account differences in network size between years we divide *Degree* by (*n* – 1), where *n* is the number of firms in the network that year (Hochberg et al., 2007; Horton et al., 2012). *Degree* therefore represents the percentage of the total number of direct connections possible a firm has (Freeman, 1979).

The second measure we employ is *Closeness. Closeness* measures the quality of relationships a firm has by measuring the shortest distance between two firms. For instance, Figure 1 shows that while Firms 2 and 4 are not directly connected, indirect information channels exist via Firms 1, 3 and 5. As a result Firms 2 and 4 have two degrees of separation. Shorter distances allow for more timely information flows. We define *Closeness* as the sum of the inverse of the shortest distance between Firm *i* and all other firms in the network (Freeman, 1979) i.e.

$$C_{i,\tau}^{C} = \sum_{j=1}^{n-1} d(i,j)^{-1}\,, \quad j \neq i \qquad (2)$$

Where *n* is the total number of firms in the network and *d(i,j)* is the shortest distance between Firm *i* and Firm *j*. We deal with the issue of firms that are isolated from the main network, either forming small disconnected networks or being completely unconnected, by setting the distance between unconnected firms to 0 (Opsahl et al., 2010).[4] This measure is normalised by dividing by *(n-1)* representing the percentage of the maximum *Closeness* possible for a given Firm *i*.

The third measure we employ is *Betweenness,* which is designed to measure the volume of information passing through and potentially controlled by a given firm. Intuitively, a company sitting between two other companies is in a position to control and restrict the flow of information between those firms, such as withholding information on potential investment opportunities (Borgatti, 2005; Freeman, 1979). However, the more connections a firm has, the weaker the ability of other firms to restrict their flow of

[3] We define a director as a director or an alternative director position held on the board of a firm for the majority of one year.
[4] For a more detailed discussion on the measurement of Closeness please refer to Freeman (1979) and Borgatti (2005). For a discussion on using the Freeman (1979) measure for disconnected networks, and the limitation of restricting the sample to the main component, refer to Omer et al (2013, p. 19 & 41).

information. In Figure 1 for instance, Firm 5 is limited in its ability to restrict information flows between firms 2 and 4 because information can also flow via firms 1 and 3. Freeman (1979) explains that the potential control for a firm *i* who sits in between two other firms, is the probability that *i* falls on a randomly selected shortest path linking *(h,j)*. Let $g(h,j)$ be the number of shortest paths linking two boards, then the probability we observe in year *t* is:

$$B^{B}_{(h,i,j)\tau} = \frac{g(h,i,j)}{g(h,j)} \tag{3}$$

Where $g(h,j)$ is the maximum number of communication paths another board could be in a position to control. Therefore, the information passing between *(h,j)* can be completely controlled by *i* when $B^{B}_{(h,i,j),\tau}$ *=1*.The overall *Betweenness* of Firm *i* is the sum of the proportions of all the shortest paths linking two firms which pass through Firm *i*:

$$C^{B}_{i,\tau} = \sum_{h<}^{n-1} \sum_{j}^{n-1} B^{B}_{(h,i,j)\tau} \text{ ,} \quad where\ h \neq i \neq j \tag{4}$$

N is the number of firms in the network and $B^{B}_{(h,i,j)}$ is defined as per Equation (3). Again, we normalise *Betweenness* by expressing it as the proportion of its maximum value possible in year t. The maximum value for $C^{B}_{i,\tau}$ is measured as $(n^{\wedge 2} - 3n + 2)/2$ (Freeman, 1979). Accordingly, the relative *Betweenness* centrality in year t is:

$$C'^{B}_{i,\tau} = \frac{2(C^{B}_{i,\tau})}{n^2 - 3n + 2} \tag{5}$$

Where $C^{B}_{i,\tau}$ is defined by Equation (4) and *n* represents the number of boards in the network.

Our fourth measure is *Eigenvector* which captures the quality of the firms with which a firm is connected. Being directly connected to a highly connected firm increases a firm's direct access to more information (Omer et al., 2013). *Eigenvector* is defined as the sum of Firm *i*'s first degree connections to all other firms (*δ(i,j)*) in the network, weighted by the connectedness of the firms to which it is connected to, i.e.

$$C^{E}_{i,\tau} = \frac{1}{\lambda} \sum_{j=1}^{n} \delta(i,j)\, C^{E}_{j,\tau} \text{ ,} \quad j \neq i \tag{6}$$

Where C^{E}_{τ} is the *Eigenvector* score for a particular firm, $\delta(i,j)$ is defined as Equation (1), and λ is a constant, defined as the maximum possible eigenvector for the given network in year *t*. Connections to highly connected firms will increase a firms *Eigenvector* score more than connections to less connected firms. Theoretically, this power may enhance a firms prospects of obtaining beneficial informational resources.

Additionally, we also generate a connectivity factor by conducting principle components analysis on the four connectivity factors. PCA gives one factor that accounts for 69% of all the variability observed in the connectivity measures. Additionally, the Cronbach's Alpha for the connectivity factor is .8479, exceeding the threshold of .8 required for a statistically reliable factor[5].

3.2 Firm Performance Measures

To estimate firm performance, we rely primarily on Tobin's Q. Tobin's Q, or common proxies for it have been previously employed in studies of board connectivity and firm performance (Andres, 2008; Horton et al., 2012; Omer et al., 2013). We estimate Tobin's Q (*TQ*) as the aggregate market value of a firm's book value of short and long-term liabilities, the liquidation value of a firm's preferred stock that is outstanding, minority interests, and the firm's market capitalisation measured at fiscal year-end, over its book value of total assets (Chung & Pruitt, 1994). We measure our firm performance measure both concurrently, one-year ahead (t+1) and additionally include Tobin's Q lagged a year to control for the possibility that past performance determines how a firm is connected.[6]

3.3 Empirical Design

We analyse the relationship between board connectivity and firm performance, by treating our data as an unbalanced panel and estimating a pooled ordinary least squares (OLS) model with year and industry dummies in the form:

$$FP_{i,\tau+t} = \alpha + \beta^1 C_{i,\tau}^{\varphi} + \sum_{k=1}^{\kappa} \delta^{\kappa} X_{i,\tau}^{\kappa} + \sum_{T=1}^{T} \psi^T Y_{\tau}^T + \sum_{\varkappa=1}^{\varkappa} \lambda^{\varkappa} I_i^{\varkappa} + \varepsilon_{i,\tau+t} \quad (7)$$

where $FP_{i,\tau+t}$ represents one of the proxies for firm performance, either in the current or following year, $C_{i,t}^{\varphi}$ represents one of the four measures of connectivity, $\boldsymbol{X}_{i,\tau}$ represents a vector of firm-level and corporate governance characteristics to control for observable factors, Y_{τ} and I_i are year and industry dummies respectively. Additionally, we cluster the standard errors by firm (Petersen, 2009). We also run a fixed effect model including a lagged dependent variable to control for potential endogeneity issues, consistent with literature in the area (Horton et al. 2012; Adam and Ferreira, 2009).

We include a number of controls in our analysis. First, we include firm size, as large firms are typically more connected and perform better (Banz, 1981; Horton et al., 2012; Omer et al., 2013). We define size as the fiscal year-end market capitalisation (*MV*). Additionally, we also control for leverage which has

[5] Additional details on the PCA factor generated can be found in Appendix 1.
[6] We also test firm performance out to *t+3*. The results are very similar to *t+1* and so are not reported for the sake of brevity.

been shown to play a role in motivating profit generation (Baker, 1973). We define leverage (*LEV*) as the book value of short and long-term debt divided by the book value of assets. Older firms are likely more established and potentially profitable and may find it easier to attract better quality directors. We measure firm age (*AGE*), as the number of years that a stock had been listed on the ASX (Barnea & Guedj, 2007; Core et al., 1999). To capture firm risk (similar to Core et al., 1999), we include the return volatility for a firm measured as the standard deviation of monthly stock returns from January to December (*RISK*) for year *t*.

We also control for the internal corporate governance of each firm based on the corporate governance index of Henry (2008), who created an index relevant to the regulatory environment in Australia based on the Australian Stock Exchange recommendations. The index assigns firms 1 point each for having the following corporate governance characteristics: more than 50% of the board as independent directors, an independent board chair, an independent audit committee, an independent remuneration committee, and independent nomination committee, a board that has less than the annual median board members, if total benefits to directors divided by revenue is greater than the annual median level and if options issued to executive directors divided by revenue is greater than the annual median level for all firms. We collect this information from the SIRCA Corporate Governance Database for each firm-year and calculate annual corporate governance index scores using the same definitions as Henry (2008). We also control for the percentage of female directors on the board, as female directors have been shown to improve firm performance (Adams & Ferreira, 2009), and given the relative scarcity of female directors, individuals may sit on a greater than average number of boards making them more connected. Finally, we capture the experience the board has in monitoring a firm, by controlling for the tenure of the board (*TEN*), defined as the average length of time the directors have served on the board (Horton et al., 2012).

To control for industry and time we create dummy variables using level 1 Industry Classification Benchmark codes and the year[7]. To remove the effect of extreme outliers on the results, we winsorize *ROA, TSR MV, LEV,* and *RISK* at the 1st and 99th percentile and *TQ* at the 5th and 95th percentile.

3.4 Data

We address whether board connectivity has an effect on firm performance by examining firms listed on the Australian Stock Exchange between 2001 and 2011. Australia provides an interesting setting to explore the impact of connectivity on firm performance as it represents a well-developed market, with a strong regulatory regime, and similar market, cultural and legal characteristics to the United States and the United Kingdom (where previous studies have been performed). Accordingly, Australia

[7] Industry dummies were excluded from tests using firm fixed effects.

provides a sound setting for acquiring additional empirical evidence that is comparable to the current literature (Horton et al., 2012; Larcker et al., 2013; Omer et al., 2013).

We first construct boardroom networks consisting of our sample firms each year between 2001 and 2011. In constructing the network, we allow information to flow bi-directionally between connected firms. We then use each of our networks to calculate annual centrality measures for each firm's board of directors. Corporate governance data, including board characteristics and membership, are collected from the Securities Industry Research Centre of Asia-Pacific (SIRCA) Corporate Governance Database.[8] Accounting and stock market data are obtained from Thomson Reuters Datastream (DS). Our sample comprises 1355 unique ASX listed firms with 11,447 unique directors and 10,599 firm year observations. We use the director board seats information from SIRCA to construct our network measures using the UCINET 6 package.

Panel A of Table 1 displays boardroom network characteristics for each sample year. On average there are 960 firms and 4,741 directors per year. We observe directors hold on average 1.25 boards seats per year, although this is declined from 1.3 in 2003 to 1.19 in 2011. We observe the maximum board seats held by a director has halved, from 12 in 2001 to six in 2011. On average, about 70% of the companies in the sample were connected to the largest network, comparable with Larcker et al. (2013) who reports an annual average of 72% for US companies, although this percentage also declines over time. The number of firms in isolated networks doubles over the sample period while the number of isolated firms (unconnected to any companies) increases slightly. It is therefore apparent that firms are becoming notably less connected, particularly following the Global Financial Crisis.

Panel B of Table 1 reports descriptive statistics for the centrality measures. Overall sample averages of *Degree*, *Closeness*, *Betweenness* and *Eigenvector* are 0.34%, 9.6%, 0.25% and 1.68% respectively. Of note, all bar *Closeness* are skewed, suggesting the means are driven by a few well connected firms. For *Closeness* we note that Australian firms are more closely connected than UK or US firms. Larcker et al. (2013) reports an overall closeness measure of 4.5% for US firms, while Horton et al. (2012) finds 8.7% for UK firms. For the same measure we find a mean of 17.4%. Annual sample statistics of the centrality measures are presented in Panel C. We observe that both *Degree* and *Closeness* decline over the sample period, consistent with Omer et al. (2013) and Larker et al. (2013). However, *Betweenness* and *Eigenvector* display no obvious trends. The variation in trends suggest that these measures are capturing different aspects of connectivity and that some aspects of connectivity are declining over time.

[8] Preparation for constructing the networks first involved identifying the directorships held by each director on a firm's board, in the same year, using director names. To ensure the accuracy of the entries, any ambiguous names between years and firms, were manually cross-checked using director information from annual reports, the Bloomberg Professional® Service people search and other websites providing director records.

[INSERT TABLE 1 HERE]

Table 2 presents descriptive and sample statistics of the firm performance measures and the control variables we employ. Panel A of Table 2 describes the distributional characteristics of the firm performance and control measures at t=0. The overall sample average of 2.015 for *TQ* is rather high, interpreted as market value of assets being about two times that of the cost to replace those assets. Omer et al. (2013) by contrast reports an average of 1.82 for US listed firms. We observe a low average *ROA* of -5.9%, which is heavily skewed as shown by the median *ROA* being 4.3%. Shultz et al. (2013) also reports negative average *ROA* for Australian listed firms over a similar period. The average *TSR* is 17.1% compared with a median of just 2.9%, indicating a strong positive skew. We also observe considerable variation in the *TSR* with a standard deviation of 75.8%. *MV* is significantly skewed to the right, with an average of $828.4 million and median of $64.79 million and considerable variation, a standard deviation of 2939.9 and an interquartile range between $14.41 million and $294.26 million. On average, firms are about 11 years old, with a median *AGE* of about 9.5 years. On average firms score 4.15 on the *CG Index* with a median of 4 and over half of all firms falling between 3 and 5. On average, 17.8% of the firm assets are funded with interest bearing debt. Directors hold their positions for about 5 to 6 years, and a very small number of firms have female directors (upper quartile range is 0).

[INSERT TABLE 2 HERE]

Panel B shows the annual averages and medians (in parenthesis) of Tobin's Q. We observe a steady run up in average *TQ* to its highest level in 2007, however, following the GFC we see a marked decline in *TQ*. Following standard practice, we use the natural log of *MV* in regressions. To smooth out the skewed distributions of *AGE*, *LEV*, and *TEN*, we take the log of the variables for the regressions. Taking the logistic transformation of *AGE* is also consistent with previous studies (e.g. Larcker et al., 2013). Additionally, we take the log of (1+ *FEM*) (Wooldridge, 2009) to ensure observations with zero female board members are included in the analysis. We deal with the skewness in *TQ* and *TSR* by taking the the natural log of *TQ*, and (1+*TSR*).

4. Results

4.1 Preliminary analysis

To investigate the relationship between connectivity and firm performance, we first estimate correlations between connectivity, current year firm performance and control variables. The estimates are presented in Table 3. The correlations show that each dimension of connectedness is correlated but not extremely highly. The strongest observations we observe are between *Degree* and the other three connectivity measures, ranging from 0.69 to 0.73. Correlations between *Closeness*, *Betweenness* and

Eigenvector are weaker, between 0.45 and 0.5. Overall, we observe that *Degree*, which is almost identical to the interlocks measure used in early studies, is highly correlated with other dimensions of connectivity, but doesn't fully explain the other dimensions. Consideration of the wider dimensions may therefore provide additional insights.

In terms of firm performance, the correlations with the connectivity estimates are extremely weak with coefficients between 0.01 and 0.17 for the connectivity measures and *ROA* and *TSR.* Conversely, the relationship between *TQ* and connectivity is negative, although still between -0.08 and -0.03. These relationships do not indicate a strong association between connectivity and firm performance. We observe strong relationships between connectivity and firm size, with coefficients between 0.3 and 0.5. Additionally, we see a strong relationship between *MV* and *ROA*, a weaker positive relationship with *CG Index,* and a strong negative relationship with risk. These are not surprising findings as larger firms generally have the ability to attract better, more connected directors and also, larger boards will tend to have higher connectivity.

[INSERT TABLE 3 HERE]

4.2 Multivariate Analysis

To investigate whether a firms positioning in the boardroom network is important for firm performance, we initially regress Tobin's Q against the five connectivity measures, using both current and one-year ahead firm performance measures. We use two regression methods, pooled OLS with time and industry dummies and fixed effects regressions where we also include the lagged dependent variable. The second regression controls for two potential sources of endogeneity, specifically omitted variables and simultaneity and is in line with previous studies in the area (Horton et al. 2012; Adam and Ferreira, 2009).

Table 4, current year Tobin's Q, presents the main results of the analysis. Overall, the results suggest that board connectivity is negatively associated with *TQ,* consistent with the general findings of Omer et al. (2013) and the board interlocks literature (Non & Franses, 2007; Santos et al., 2009), and with the correlation coefficients shown in Table 3. Specifically, we observe strong negative coefficients for all five connectivity measures at the 1% level with the exception of the fixed effects regression of *DEG* and *BTW,* which are significant at the 5% level. The result is also consistent irrespective whether we consider a simple pooled OLS regression with year and industry dummies or a fixed effect regression model with a lagged dependent variable and year dummies. Of note, the coefficients reduce in size when we run the fixed effects models, generally to about 1/3rd the size of the pooled OLS, but the significance generally stays strong. We also find that our regressions explain at least 20% of the variation in Tobin's Q.

[INSERT TABLE 4 HERE]

With regard to the control variables, we observe that larger firms are consistently strongly associated with higher Tobin's Q as is risk, suggesting larger companies and riskier companies have higher Tobin's Q. In contrast, younger firms typically have lower Tobin's Q, and in the fixed effects model we find that more highly levered firms have higher Tobin's Q, while firms with higher internal corporate governance have lower Tobin's Q. We also find that the lag of Tobin's Q is consistently positive and significant, denoting a highly persistent firm performance measure over time suggesting that historical factors, such as the board's selection process, may influence current performance.

Table 5 presents the regression results for Tobin's Q in the following year (*t+1*) against the five connectivity measures. The results are broadly supportive of the findings in Table 4. We observe significantly negative coefficients for all the connectivity variables when we use pooled OLS. The coefficients drop markedly when we employ fixed effects and include the lag of the dependent variable, but remain statistically significant for all the measures with the exception of *BTW*, albeit at a lower significance level for *DEG* and *EIG*. The control variables are also broadly consistent with the results for the current year Tobin's Q, with the exception of *MV*, which loses significance in the fixed effects regressions.

[INSERT TABLE 5 HERE]

Overall, our main results suggest that higher levels of connectivity are detrimental to firm performance when measured using Tobin's Q. The harmful impacts occur irrespective of the connectivity dimension that we consider, be it direct connections, network centrality, information flows and the ability to control the flow of information, or the quality of a company's connections. The finding of the negative impact of direct connections (*DEG*) is consistent with the interlock literature which has found that more director connections harms firm performance. The literature that considers wider connectivity dimensions have found mixed results. Of the studies that consider either Tobin's Q or the market to book ratio (a common proxy for Tobin's Q), we support Andres et al. (2013), who study connectivity in Germany, and Omer et al. (2013) in the United States, who both find that on average firm performance is lower for firms with highly connected boards.

4.3 Robustness Analysis

To ensure the robustness of our main finding we test a number of additional specifications including using alternative measures of firm performance, testing for non-linearity in the relationship, focusing on those firms associated with the main network, employing Fama-Macbeth regressions and controlling for reverse causality.

4.3.1. Alternative Firm Performance Measures

While Tobin's Q is a popular measure of firm performance, other measures of firm performance have been employed in previous studies considering board connectivity. Two other measures which have been used in several prior studies are the return on assets (Horton et al. 2012; Omer et al. 2013; Larcker et al. 2013) and stock returns (Horton et al. 2012; Larcker et al. 2013). Given that both Horton et al. (2013) and Larcker et al. (2013) findings contrast with our own, considering alternative firm performance measures may help to shed light on whether the mixed results in prior literature is due to differences in the measure of firm performance.

We re-run our regression specification where we include fixed effects and the lagged dependent variable, employing current year return on assets and total stock returns. We define *ROA* as earnings before interest, taxes, depreciation and amortization (EBITDA) scaled by the average of book value total assets. Using the operating ROA reduces the impact of factors unrelated to performance such as accounting decisions regarding depreciation (Anderson & Reeb, 2003; Andres, 2008; Omer et al., 2013). We also test the current year total stock returns (*TSR*) using the adjusted closing price of the firm's security at the end of December and incorporating gross dividends, which we assume were reinvested at the closing price on the firms ex-dividend date (Core et al., 1999). Correlation coefficients in Table 3 indicate that while there is a negative relationship between connectivity and Tobin's Q, there are weak positive relationships with both *ROA* and *TSR*.

The results in Table 6 show strong support for our earlier findings irrespective of the measure of firm performance. For both *ROA* and *TSR* we observe statistically significant negative relationships with all five connectivity measures, significant at the 1% level. If anything, the results of our alternative firm performance measures display stronger significance than for the *TQ* results. The results also suggest that differences in the measure of firm performance cannot explain the differences we observe with Larcker et al. (2013) and Horton et al. (2012).

[INSERT TABLE 6 HERE]

4.3.2 **Non-linearity in the effect of board connectivity**

While the linear results suggest a negative relationship between connectivity and firm performance, it is likely that the relationship is more complicated than a simple linear relationship. While large levels of connectivity are likely to be harmful, it is possible that some connectivity may have more positive implications for firm performance as was observed in Santos et al. (2009). To test this proposition, we create two dummy variables for each of the connectivity variables, high and low. For each year we rank the firms based on their connectivity score for each dimension and assign a 1 to the high dummy if they are in the highest 25%, and 1 to the low dummy if they are in the lowest 25%. We then regress the high and low dummies against Tobin's Q in the current and next year (t+1).

The results for the non-linearity testing are presented in Table 7, based on the fixed effects model with LDV. We find evidence that a little connectivity produces a positive impact, while large amounts result in a reduction in firm performance. Specifically, when we consider *TQ* in the current year we observe positive coefficients for the low connectivity group for four of the five groups, and only *DEG* has an insignificant coefficient. The high group in contrast has significantly negative coefficients for all connectivity measure except *BTW*. The results for t+1 are weaker, we find significant positive coefficients for *CLO*, *EIG* and *CONN* for the low connectivity groups and significantly negative coefficients for the same connectivity measures for the high group. This overall suggest that low levels of connectivity appear to be beneficial, possibly bringing in enough information and resources to augment the management team without overloading the board or unduly undermining board monitoring. However, high connectivity reduces firm performance.

[INSERT TABLE 7 HERE]

4.3.3 Main Component

The full sample we employ contains a number of firms that are either completely isolated, with no directors who sit on the boards of other publicly listed companies, or small networks made up of a few companies who share directors in common, but who are not connected to the main network. We remove these extremes examples of low connectivity and re-run the main model with just the main network companies. The results, shown in Table 8, support the earlier findings. We find significant negative relationships between the connectivity measures and *TQ* in the current year for all except *DEG*. In t+1 we again observe weaker significance, with just *CLO* and *EIG* significant, indicating that being more central and being connected to other highly connected firms is associated with reduced firm performance.

[INSERT TABLE 8 HERE]

4.3.4 Fama-MacBeth

We employ a commonly used alternate estimation method to ensure the results are not driven by the choice of model, specifically the Fama-MacBeth (FMB) (1973) two stage method. In the first stage we estimate a cross-sectional regression of firm performance on each of the connectivity measures for each year in our sample between 2001 and 2011. After estimating these regressions, we average each of the cross-sectional coefficients over the number of years in the sample.

Table 9 reports the results of the Fama-MacBeth regressions. The results are broadly supportive of the earlier main model findings. We observe that irrespective of the aspect of connectivity captured, more connected firms appear to perform worse, or at best, no better than less connected firms. Specifically, we observe negative and significant coefficients for all connectivity measures for *TQ* in the current year, and for *DEG*, *CLO* and *CONN* in t+1. Additionally, the control variables remain consistent with the earlier pooled OLS estimates. Overall, the different estimation method does not appear to impact the results substantially.

[INSERT TABLE 9 HERE]

4.3.5 Change Regressions

In Section 4.2 we employed Equation (7) including fixed effects with the lag of the firm performance measure, to control for unobserved factors such as a firm's board selection process and director preferences. These specifications have been used in other corporate governance (Adams and Ferreria, 2009) and board connectivity studies (Horton et al., 2012) to control for potential sources of endogeneity. While endogeneity does not appear to be a concern, we undertake additional testing to control for potential reverse causality. Specifically, the network literature argues that if a company views connectivity as a beneficial governance mechanism, firms might increase connectivity by appointing more connected directors to a board to improve firm performance. An alternative interpretation might be that better performing firms are able to attract better quality, and therefore, more connected directors. To test for this, we look at changes in connectivity on changes in firm performance where we measure the difference in connectivity and firm performance measures between years t_0 and t_{-1}, and also t_{-1} - t_{-2} for firm performance (Andres, 2013; Yermack, 1996).[9] Following prior research, we also include changes in the control variables (t_0 - t_{-1}) that we employed earlier. Year and industry dummies are included with standard errors clustered by firm.

Table 10 provides the estimates of the change regressions. The results show no significant association between firm performance changes and the contemporaneous changes in connectivity. There is weak evidence that changes in past performance increases the *Eigenvector* coefficient. This suggests that better past performance improves the boards connections to better connected boards, possibly through the firm's board members being selected onto other boards or attracting better quality new directors.

[9] Andres (2013) employs changes in board centrality measures on stock returns, and Yermack (1996) looks at changes in board size on stock returns. We include the four firm performance measures used in this study for a more robust conclusion. Additional to the controls used in the previous studies, we control for board size and risk. A change in board size is expected to have an effect on connectivity and a positive change in risk may prompt firms to increase connections in search for a stronger resource base.

[INSERT TABLE 10 HERE]

Overall the results strongly dismiss evidence that connected boards add value to firms. While the resource dependency theory argues that connected directors bring valuable resources to the firm that managers can exploit to improve firm performance, we find no evidence that this is the case. Rather, we find that either connected board members are undermining the monitoring role of directors, they are bringing in poor quality information or that they are bringing in too much information for the board to deal with. These results are robust to alternative estimation methods, and the inclusion of past firm performance or estimating the results using change variables, where the relationship becomes broadly insignificant.

5. Conclusions

Resource dependency theory asserts that the board provides managers with additional resources, such as connections, experience, inference and counsel, which can be used to drive firm performance (Hillman & Dalziel, 2003; Pfeffer & Salancik, 1978). By extension, companies can obtain external resources through connections to other boards (Wasserman & Faust, 1994). Therefore, well-connected directors have been argued as adding value by being more able beneficial in the resource dependency role. Prior research has established that information flows between firms through multiple dimensions of board connectivity, however the findings to date do not provide conclusive evidence on the economic effect of being well connected. We contribute to this literature stream using four social network measures that capture different aspects of a board's connectedness (Freeman, 1979; Opsahl et al., 2010), the quantity (*Degree*), quality and speed (*Closeness*) of information, the ability to control the network flow (*Betweenness*), and the power to access more information through connections with the best-connected firms (*Eigenvector*), and a connectivity factor.

The results show that board connectivity plays no role in increasing firm performance, and for the most part actually results in worse firm performance. Our findings are supportive of Omer et al. (2013) and Andres et al. (2013) who both find that even when considering a broader definition of connectivity than is employed in the interlock literature, connectivity is not a beneficial board characteristic. We perform a number of robustness tests including controlling for alternative measures of firm performance, alternative estimation methods and looking at the impact of changes in connectivity on changes in firm performance. Our results remain broadly supportive. Of note, we do find evidence that small amounts of connectivity are beneficial, with positive relationships between connectivity and firm performance for the least connected firms and negative relationships for the most connected firms. Further research is needed to determine the optimal amount of connectivity for firms. A notable implication of our findings is the need for more suitable individuals to increase the pool of directors available such that the number of interlocks and therefore connectivity can be reduced.

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Appendix I

Principal Components Analysis

The PCA results for eigenvalues show that the eigenvalue for the first component (2.76) is much larger than than the second component (0.56) and accounts for 69% of the total variance. This indicates that the connectivity measures are unidimensional.

PCA Output:

Number of observations: 10559

Number of Components with eigenvalue>1: 1

Trace: 4

Rho: 0.6912

Rotation: (unrotated = principal)

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	*2.76463*	*2.20041*	*0.6912*	*0.6912*
Comp2	0.564221	0.0432384	0.1411	0.8322
Comp3	0.520983	0.370818	0.1302	0.9625
Comp4	0.150164	.	0.0375	1

Principal components (eigenvectors)

Variable	Comp1	Unexplained
DEGREE	0.5696	0.1029
CLOSE	0.4796	0.3641
BETWEEN	0.4783	0.3674
EIGEN	0.4655	0.4009

Cronbach's Alpha Validity Test

To test the validity and reliability of the connectivity measures used to construct the measure *Conn*, we compute Cronbach's Alpha using standardized variables (mean 0, standard deviation 1).

Cronbach's Alpha output:

Test scale = mean (standardized items)

Item	Obs	Sign	item-test correlation	item-rest correlation	average inter-item correlation	alpha

DEGREE	10559	+	0.9406	0.8831	0.4585	0.7175
CLOSE	10559	+	0.7968	0.6337	0.6175	0.8288
BETWEEN	10559	+	0.797	0.6341	0.6172	0.8287
EIGEN	10559	+	0.7803	0.6077	0.6357	0.8396
Test scale					*0.5822*	*0.8479*

Inter-item correlations (obs=10559 in all pairs)

	DEGREE	*CLOSE*	*BETWEEN*	*EIGEN*
DEGREE	1			
CLOSE	0.7334	1		
BETWEEN	0.7039	0.4698	1	
EIGEN	0.6805	0.4378	0.468	1

The test score 0.8479 is greater than 0.80, therefore the variables used are considered to be statistically reliable.

Figure 1: Graph Illustration of Connected Boards

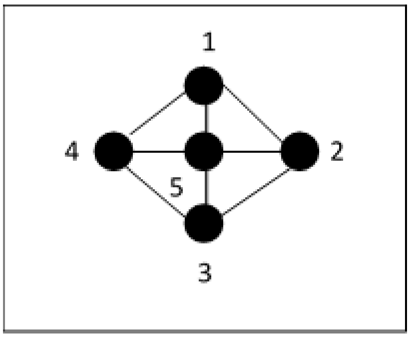

Figure 2: 2001 Aggregate Boardroom Network of Australian Listed Firms

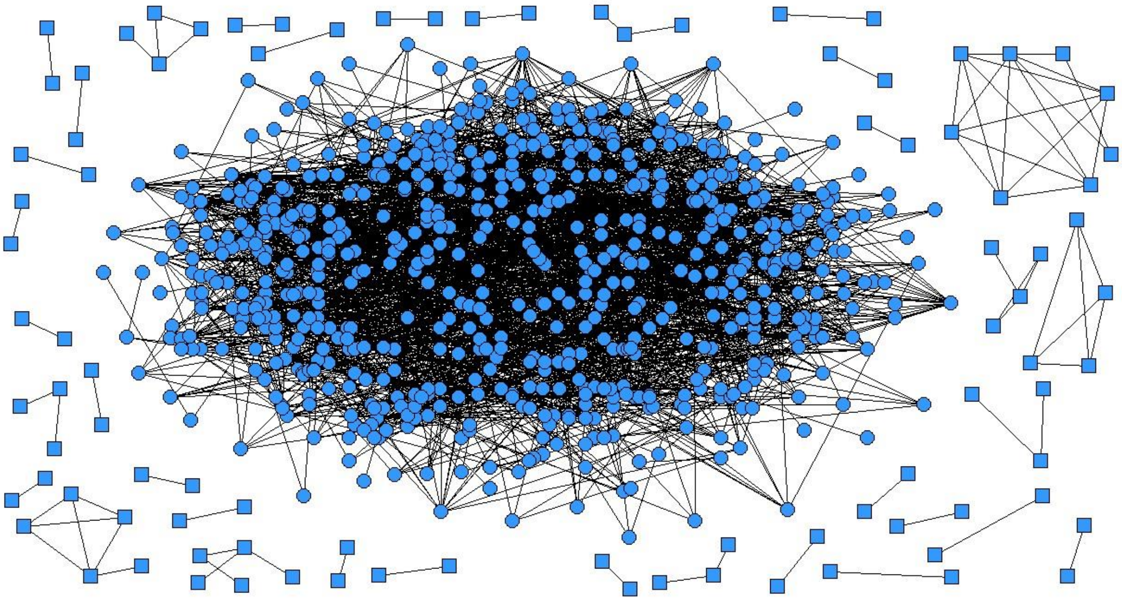

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Figure 2 presents a visual representation of the network of Australian listed firms in 2001. The figure demonstrates that Australia has a very significant main component, represented by the blue circles comprising 73.1% of the sample firms. These firms are all interconnected, where the firms on the fringes are less connected than those in the centre. The figure also contains a number of smaller networks, disconnected from the main component, represented by blue squares and ranging from two to eight firms. In total, 9.5% of the sample firms in 2001 are in such disconnected networks. The remaining 17.4% of firms, not shown in the figure, are isolates; firms with no directors in common with any other publicly listed board

Table 1.
Sample and Descriptive Statistics of Boardroom Network Characteristics and Connectivity measures

Panel A: Boardroom network characteristics

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
N Firms	971	958	992	987	1,020	1,034	1,021	966	941	900	769	10,559
N Directors	4,884	4,838	4,835	4,746	4,887	5,021	5,093	4,808	4,633	4,459	3,943	52,147
N Directorates	6,199	6,179	6,283	6,062	6,219	6,361	6,346	5,917	5,654	5,392	4,673	65,285
Avg Directorships	1.27	1.28	1.30	1.28	1.27	1.27	1.25	1.23	1.22	1.21	1.19	1.25
Max Directorships	12	11	11	8	7	7	7	7	7	7	6	8.20
Max board size	21	18	19	20	16	17	17	16	17	16	17	17.4
Main (Largest)	73.1	74.1	74.5	72.2	71.8	72.7	70.0	65.2	65.1	64.7	57.6	69.5
Other components %	9.5	7.8	6.7	8.3	8.6	9.7	11.1	13.9	11.8	13.0	18.5	10.6
Isolated firms %	17.4	18.1	18.9	19.5	19.6	17.6	18.9	20.9	23.1	22.3	23.9	19.9

Panel B: Descriptive statistics of connectivity

	Mean	SD	P25	Median	P75	Skew	Obs
DEG	0.0034	0.0035	0.0010	0.0022	0.0050	1.647	10559
CLO	0.0957	0.0694	0.0013	0.1147	0.1495	-0.300	10599
BTW	0.0025	0.0049	0.0000	0.0000	0.0030	3.9075	10599
EIG	0.0168	0.0424	0.000	0.0005	0.0101	4.3226	10599

Panel C: Sample averages (medians) of connectivity by year

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
DEG	0.0039	0.0040	0.0041	0.0037	0.0034	0.0033	0.0031	0.0030	0.0029	0.0028	0.0029	0.0034
	(0.0031)	(0.0031)	(0.0030)	(0.0030)	(0.0029)	(0.0019)	(0.0020)	(0.0021)	(0.0021)	(0.0022)	(0.0026)	(0.0022)
CLO	0.112	0.116	0.119	0.109	0.101	0.103	0.094	0.081	0.075	0.075	0.057	0.096
	(0.136)	(0.138)	(0.143)	(0.133)	(0.125)	(0.123)	(0.114)	(0.101)	(0.095)	(0.096)	(0.073)	(0.115)
BTW	0.0025	0.0026	0.0025	0.0024	0.0026	0.0026	0.0025	0.0023	0.0027	0.0026	0.0026	0.00252
	(0.0002)	(0.0000)	(0.0003)	(0.0001)	(0.0002)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
EIG	0.0068	0.0194	0.0203	0.0170	0.0154	0.0164	0.0180	0.0173	0.0185	0.0184	0.0177	0.01682
	(0.0001)	(0.0013)	(0.0020)	(0.0007)	(0.0006)	(0.0007)	(0.0005)	(0.0003)	(0.0003)	(0.0006)	(0.0002)	(0.0005)

Presented here are various statistics for the sample of Australian listed firms from 2001 through 2011. Panel A displays annual network characteristics of the aggregate boardroom network. *Directors* include all directors and alternative directors. A directorship is defined here as a board position held by one director in the respective year. A component represents a subset of an entire network of a group of firms that are directly or indirectly connected. The main component is the largest group of firms directly or indirectly connected through shared directors. Isolated firms are those with no connections in the network. Panel B presents descriptive statistics for the connectivity measures *Degree, Closeness, Betweenness and Eigenvector* (see Equations (1), (2), (5) and (6) respectively in Section 3.1). *DEG* is defined as the number of first degree links from firm *i* to all other firms in the network; *CLO* denotes the sum of the inversed shortest distances between firm *i* and all other directly and indirectly connected firms; and *BTW* is the number of times a firm occurs on the shortest path linking two other firms. *EIG* denotes the connectivity a firms direct connections. All connectivity measures are normalised to represent the proportion of the maximum possible score of each measure. Panel D displays annual sample statistics of averages (medians) of the four centrality measures. All data are collected from Securities Industry Research Centre of Asia-Pacific (SIRCA) Corporate Governance Database.

Table 2.
Descriptive and Sample Statistics of Firm Performance

Panel A: Descriptive statistics of firm performance

	Mean	SD	Q25	Median	Q75	Skew	Obs
TQ	2.015	1.550	1.007	1.402	2.389	1.737	10214
ROA	-0.059	0.409	-0.152	0.043	0.149	-2.179	10383
TSR	0.171	0.758	-0.314	0.029	0.414	1.598	10201
MV($M)	828.37	2939.9	14.41	64.79	294.26	6.05	10214
AGE(years)	10.92	7.71	5.46	9.53	14.54	1.22	10324
LEV	0.178	0.255	0.000	0.087	0.277	2.962	10468
RISK	0.610	0.330	0.320	0.542	0.818	1.042	10185
CG Index	4.154	1.502	3	4	5	-0.145	10559
FEM	0.043	0.089	0.000	0.000	0.000	2.453	10555
TEN(years)	6.033	3.745	3.289	5.149	7.788	1.371	10559

Panel B: Sample averages (medians) of firm performance by year

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL
TQ	1.708	1.800	1.801	2.021	2.090	2.267	2.660	2.063	1.846	1.920	1.896	2.015
	(1.178)	(1.259)	(1.247)	(1.480)	(1.561)	(1.746)	(1.921)	(1.394)	(1.174)	(1.275)	(1.285)	(1.402)

Presented here are firm performance summary statistics of the sample of Australian listed firms from 2001 through 2011, Panel A provides descriptive statistics for each of the firm performance measures while Panel B displays the sample averages (medians) of firm performance measures for each year. *ROA* is measured as earnings before interest, tax, depreciation and amortization (EBITDA) scaled by the book value of average total assets; *TQ* is total liabilities + preferred stock + market capitalisation (fye) + minority interests / total assets; *TSR* represents the annual total stock return measured at calendar year-end including dividends. *MV* represents firm size, the market capitalisation measured at fiscal year-end expressed in millions (common shares outstanding*closing stock price); *LEV* is firm leverage, long + short term debt/total assets; *AGE* is firm age, the number of prior years the firm appears in Thompson Reuters Datastream; *RISK* represents firm risk, the firm's stock return volatility, measured as the standard deviation of the previous calendar year's monthly stock return; *CG Index* represents the Harris (2008) corporate governance index score for the firm; *FEM* represents the ratio of female directors to board size; *TEN* is the average tenure of the board, measured by the total number of years served by all current directors on the board divided by board size; *DUAL* is duality, which is a dummy variable that equals 1 if the CEO is chairman of the board, and 0 otherwise. Accounting data are collected at fiscal year-end and measured in year *t*. All data are collected from Thomson Reuters Datastream.

Table 3.
Pearson Pairwise Correlations

	ROA	*TQ*	*TSR*	*DEG*	*CLO*	*BTW*	*EIG*	*MV*	*LEV*	*AGE*	*RISK*	*CG Index*	*FEM*	*TEN*
ROA	1													
TQ	-0.264	1												
TSR	0.192	0.102	1											
DEG	0.138	-0.071	0.042	1										
CLO	0.161	-0.060	0.064	0.734	1									
BTW	0.084	-0.034	0.031	0.705	0.471	1								
EIG	0.122	-0.074	0.013	0.682	0.440	0.472	1							
MV	0.400	0.118	0.134	0.474	0.418	0.350	0.423	1						
LEV	-0.005	-0.060	-0.065	0.086	0.074	0.057	0.074	0.096	1					
AGE	0.025	-0.103	-0.003	0.127	0.012	0.116	0.137	0.131	0.048	1				
RISK	-0.427	0.126	-0.045	-0.276	-0.301	-0.165	-	-0.552	-0.073	-0.046	1			
CG Index	0.1035	-0.078	0.014	0.078	0.105	0.096	0.104	0.248	0.017	-0.028	-0.155	1		
FEM	0.096	-0.028	-0.000	0.151	0.134	0.110	0.181	0.200	0.039	0.018	-0.126	0.038	1	
TEN	0.236	-0.102	0.077	-0.007	-0.041	-0.018	0.072	0.167	0.052	0.359	-0.269	0.073	0.048	1

Provided here are Pearson pairwise correlation coefficients between the dependant variables ROA, TQ, TSR and independent variables used in Equation (7). The sample includes a total of 10599 firm-year observations of Australian listed firms over 2001 through 2011. Firms with missing observations are excluded from the tests. DEG, CLO, BTW and EIG denote the connectivity measure Degree, Closeness, Betweenness and Eigenvector defined at Equations (1), (2), (5) and (6) respectively, in Section 3.1. ROA is measured as earnings before interest, tax, depreciation and amortization (EBITDA) scaled by the book value of average total assets; TQ is total liabilities + preferred stock + market capitalisation (fye) + minority interests / total assets; TSR represents the annual total stock return measured at calendar year-end including dividends. MV represents firm size, the market capitalisation measured at fiscal year-end expressed in millions (common shares outstanding*closing stock price); LEV is firm leverage, long + short term debt/total assets; AGE is firm age, the number of prior years the firm appears in Thompson Reuters Datastream; RISK represents firm risk, the firm's stock return volatility, measured as the standard deviation of the previous calendar year's monthly stock return; CG Index represents the Harris (2008) corporate governance index score for the firm; FEM represents the ratio of female directors to board size; TEN is the average tenure of the board, measured by the total number of years served by all current directors on the board divided by board size; DUAL is duality, which is a dummy variable that equals 1 if the CEO is chairman of the board, and 0 otherwise. Accounting and corporate governance data are collected at fiscal year-end in year t. Accounting and stock market data are obtained from Thomson Reuters Datastream. Corporate governance data are collected from Securities Industry Research Centre of Asia-Pacific (SIRCA) Corporate Governance Database.

Table 4.
Regression Results for Current Year Tobin's Q on Firm Connectivity Measures

	TQ_OLS	*TQ_FE*	*TQ_OLS*	*TQ_FE*	*TQ_OLS*	*TQ_FE*	*TQ_OLS*	*TQ_FE*	*TQ_OLS*	*TQ_FE*
Constant	-0.700***	-1.323***	-0.608***	-1.295***	-0.653***	-1.329***	-0.739***	-1.330***	-0.817***	-1.354***
	(0.0882)	(0.108)	(0.0871)	(0.108)	(0.0876)	(0.109)	(0.0896)	(0.109)	(0.0919)	(0.109)
DEG	-22.25***	-6.893**								
	(3.386)	(2.960)								
CLO			-1.013***	-0.486***						
			(0.164)	(0.125)						
BTW					-9.862***	-2.944**				
					(1.805)	(1.271)				
EIG							-1.598***	-0.574***		
							(0.216)	(0.149)		
CONN									-0.0525***	-0.0222***
									(0.00697)	(0.00570)
MV	0.105***	0.148***	0.101***	0.149***	0.0955***	0.147***	0.100***	0.147***	0.107***	0.149***
	(0.00661)	(0.00880)	(0.00636)	(0.00879)	(0.00616)	(0.00875)	(0.00629)	(0.00871)	(0.00661)	(0.00883)
LEV	0.00369	0.334***	-0.00376	0.331***	0.000349	0.334***	-0.00447	0.334***	0.00331	0.332***
	(0.0852)	(0.0541)	(0.0850)	(0.0537)	(0.0852)	(0.0540)	(0.0856)	(0.0540)	(0.0848)	(0.0540)
AGE	-0.0834***	-0.0937**	-0.0934***	-0.0980***	-0.0919***	-0.0999***	-0.0894***	-0.102***	-0.0832***	-0.0954***
	(0.0173)	(0.0368)	(0.0174)	(0.0366)	(0.0174)	(0.0368)	(0.0173)	(0.0368)	(0.0173)	(0.0367)
RISK	0.432***	0.256***	0.423***	0.255***	0.435***	0.256***	0.439***	0.259***	0.431***	0.256***
	(0.0326)	(0.0241)	(0.0325)	(0.0241)	(0.0325)	(0.0242)	(0.0327)	(0.0241)	(0.0325)	(0.0241)
CG Index	-0.00655	-0.0203***	-0.00494	-0.0200***	-0.00619	-0.0198***	-0.00656	-0.0197***	-0.00506	-0.0201***
	(0.00731)	(0.00535)	(0.00731)	(0.00534)	(0.00727)	(0.00533)	(0.00725)	(0.00533)	(0.00729)	(0.00534)
FEM	-0.195	0.0469	-0.208	0.0613	-0.224	0.0488	-0.178	0.0628	-0.167	0.0637
	(0.145)	(0.117)	(0.148)	(0.117)	(0.145)	(0.118)	(0.145)	(0.117)	(0.145)	(0.117)
TEN	-0.0345*	0.00629	-0.0324	0.00327	-0.0290	0.00691	-0.0250	0.00767	-0.0361*	0.00373
	(0.0208)	(0.0192)	(0.0207)	(0.0191)	(0.0207)	(0.0193)	(0.0206)	(0.0193)	(0.0207)	(0.0192)
TQ t-1		0.346***		0.344***		0.345***		0.346***		0.345***
		(0.0151)		(0.0151)		(0.0151)		(0.0151)		(0.0151)
Observations	9,924	9,630	9,924	9,630	9,924	9,630	9,924	9,630	9,924	9,630
R-squared	0.222	0.349	0.220	0.351	0.216	0.349	0.220	0.350	0.224	0.351
YEAR	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
FIXED EFFECTS	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Presents regression results for pooled OLS (*OLS*) and firm fixed effect regressions (*FE*) for a sample of Australian listed securities between 2001 and 2011. *DEG, CLO, BTW* and *EIG* denote the connectivity measure *Degree*, *Closeness*, *Betweenness* and *Eigenvector* defined at Equations (1), (2), (5) and (6) respectively, in Section 3.1 while *CONN* is a PCA factor generated from the four connectivity measures, *TQ* is defined as total liabilities + preferred stock + market capitalisation (fye) + minority interests / total assets. *MV* represents firm size, the market capitalisation measured at fiscal year-end expressed in millions (common shares outstanding*closing stock price); *LEV* is firm leverage, long + short term debt/total assets; *AGE* is firm age, the number of prior years the firm appears in Thompson Reuters Datastream; *RISK* represents firm risk, the firm's stock return volatility, measured as the standard deviation of the previous calendar year's monthly stock return; *CG Index* represents the Harris (2008) corporate governance index score for the firm; *FEM* represents the ratio of female directors to board size; *TEN* is the average tenure of the board, measured by the total number of years served by all current directors on the board divided by board size; *TQ t-1* is a lagged dependent variable. *YEAR* and *INDUSTRY* are year and industry dummies respectively. Accounting and corporate governance data are collected at fiscal year-end in year *t.* Accounting and stock market data are obtained from Thomson Reuters Datastream. Corporate governance data are collected from Securities Industry Research Centre of Asia-Pacific (SIRCA) Corporate Governance Database. Standard errors are clustered by firm and presented in parentheses. * denotes significant at 10%, ** denotes significant at 5% and *** denotes significant at 1%.

Table 5.
Regression Results for Next Year Tobin's Q on Firm Connectivity Measures

	TQ t+1_OLS	*TQ t+1_FE*	*TQ t+1_OLS*	*TQ t+1_FE*	*TQ t+1_OLS*	*TQ t+1_FE*	*TQ t+1_OLS*	*TQ t+1_FE*	*TQ t+1_OLS*	*TQ t+1_FE*
Constant	-0.188**	0.331***	-0.135	0.357***	-0.155*	0.327***	-0.210**	0.326***	-0.253***	0.309**
	(0.0901)	(0.125)	(0.0883)	(0.125)	(0.0891)	(0.125)	(0.0915)	(0.125)	(0.0940)	(0.126)
DEG	-12.92***	-5.919*								
	(3.423)	(3.309)								
CLO			-0.629***	-0.435***						
			(0.171)	(0.161)						
BTW					-4.848***	-1.086				
					(1.736)	(1.350)				
EIG							-0.914***	-0.439**		
							(0.207)	(0.183)		
CONN									-0.0300***	-0.0165***
									(0.00704)	(0.00639)
MV	0.0581***	0.00811	0.0562***	0.00917	0.0521***	0.00730	0.0554***	0.00738	0.0595***	0.00868
	(0.00676)	(0.00929)	(0.00653)	(0.00939)	(0.00628)	(0.00924)	(0.00641)	(0.00923)	(0.00676)	(0.00931)
LEV	0.00575	0.198***	0.00227	0.196***	0.00281	0.198***	0.000182	0.198***	0.00508	0.196***
	(0.0864)	(0.0584)	(0.0863)	(0.0577)	(0.0866)	(0.0583)	(0.0867)	(0.0584)	(0.0862)	(0.0582)
AGE	-0.0753***	-0.113**	-0.0810***	-0.116**	-0.0811***	-0.119**	-0.0791***	-0.120**	-0.0754***	-0.115**
	(0.0177)	(0.0476)	(0.0177)	(0.0473)	(0.0178)	(0.0475)	(0.0177)	(0.0475)	(0.0177)	(0.0474)
RISK	0.337***	0.162***	0.331***	0.160***	0.339***	0.162***	0.341***	0.164***	0.336***	0.162***
	(0.0330)	(0.0278)	(0.0329)	(0.0278)	(0.0330)	(0.0279)	(0.0331)	(0.0279)	(0.0329)	(0.0278)
CG Index	-0.00328	-0.0145**	-0.00228	-0.0143**	-0.00325	-0.0141**	-0.00327	-0.0140**	-0.00247	-0.0144**
	(0.00776)	(0.00674)	(0.00775)	(0.00674)	(0.00774)	(0.00672)	(0.00773)	(0.00672)	(0.00775)	(0.00673)
FEM	-0.0904	-0.0524	-0.0979	-0.0393	-0.111	-0.0537	-0.0818	-0.0405	-0.0758	-0.0404
	(0.157)	(0.136)	(0.158)	(0.136)	(0.157)	(0.137)	(0.157)	(0.136)	(0.157)	(0.136)
TEN	-0.0182	0.0529**	-0.0176	0.0501**	-0.0142	0.0544**	-0.0125	0.0542**	-0.0191	0.0512**
	(0.0213)	(0.0238)	(0.0213)	(0.0237)	(0.0214)	(0.0239)	(0.0213)	(0.0238)	(0.0213)	(0.0238)
TQ t-1		0.115***		0.114***		0.115***		0.115***		0.114***
		(0.0160)		(0.0160)		(0.0160)		(0.0160)		(0.0160)
Observations	9,509	9,228	9,509	9,228	9,509	9,228	9,509	9,228	9,509	9,228
R-squared	0.179	0.139	0.178	0.140	0.176	0.138	0.178	0.139	0.179	0.139
YEAR	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
FIXED EFFECTS	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Presents regression results for pooled OLS (*OLS*) and firm fixed effect regressions (*FE*) for a sample of Australian listed securities between 2001 and 2011. *DEG, CLO, BTW* and *EIG* denote the connectivity measure *Degree*, *Closeness*, *Betweenness* and *Eigenvector* defined at Equations (1), (2), (5) and (6) respectively, in Section 3.1 while *CONN* is a PCA factor generated from the four connectivity measures, *TQ_t+1* is defined as total liabilities + preferred stock + market capitalisation (fye) + minority interests / total assets for the next year. *MV* represents firm size, the market capitalisation measured at fiscal year-end expressed in millions (common shares outstanding*closing stock price); *LEV* is firm leverage, long + short term debt/total assets; *AGE* is firm age, the number of prior years the firm appears in Thompson Reuters Datastream; *RISK* represents firm risk, the firm's stock return volatility, measured as the standard deviation of the previous calendar year's monthly stock return; *CG Index* represents the Harris (2008) corporate governance index score for the firm; *FEM* represents the ratio of female directors to board size; *TEN* is the average tenure of the board, measured by the total number of years served by all current directors on the board divided by board size; *TQ t-1* is a lagged dependent variable. *YEAR* and *INDUSTRY* are year and industry dummies respectively. Accounting and corporate governance data are collected at fiscal year-end in year *t*. Accounting and stock market data are obtained from Thomson Reuters Datastream. Corporate governance data are collected from Securities Industry Research Centre of Asia-Pacific (SIRCA) Corporate Governance Database. Standard errors are clustered by firm and presented in parentheses. * denotes significant at 10%, ** denotes significant at 5% and *** denotes significant at 1%.

Table 6.
Regression Results for Current Year ROA and Total Stock Return on Firm Connectivity Measures

	ROA_CY	*ROA_CY*	*ROA_CY*	*ROA_CY*	*ROA_CY*	*RET_CY*	*RET_CY*	*RET_CY*	*RET_CY*	*RET_CY*
Constant	-0.739***	-0.722***	-0.744***	-0.745***	-0.762***	-0.639***	-0.591***	-0.650***	-0.654***	-0.699***
	(0.0769)	(0.0770)	(0.0768)	(0.0769)	(0.0775)	(0.129)	(0.130)	(0.129)	(0.129)	(0.129)
DEG	-5.841***					-13.17***				
	(2.044)					(3.011)				
CLO		-0.310***					-0.830***			
		(0.0905)					(0.153)			
BTW			-2.706***					-4.976***		
			(0.857)					(1.394)		
EIG				-0.380***					-1.462***	
				(0.145)					(0.170)	
CONN					-0.0166***					-0.0436***
					(0.00405)					(0.00575)
MV	0.0688***	0.0692***	0.0685***	0.0681***	0.0694***	0.0526***	0.0541***	0.0516***	0.0516***	0.0546***
	(0.00574)	(0.00570)	(0.00570)	(0.00567)	(0.00573)	(0.00925)	(0.00919)	(0.00927)	(0.00922)	(0.00924)
LEV	-0.310***	-0.312***	-0.311***	-0.310***	-0.311***	-0.289***	-0.293***	-0.289***	-0.289***	-0.291***
	(0.0474)	(0.0471)	(0.0472)	(0.0474)	(0.0471)	(0.0613)	(0.0605)	(0.0612)	(0.0608)	(0.0609)
AGE	-0.00843	-0.0130	-0.0136	-0.0156	-0.0105	0.0367	0.0277	0.0245	0.0201	0.0340
	(0.0268)	(0.0267)	(0.0268)	(0.0268)	(0.0267)	(0.0447)	(0.0440)	(0.0444)	(0.0440)	(0.0441)
RISK	-0.0682***	-0.0691***	-0.0681***	-0.0663***	-0.0680***	0.189***	0.186***	0.189***	0.195***	0.189***
	(0.0209)	(0.0209)	(0.0209)	(0.0209)	(0.0209)	(0.0321)	(0.0321)	(0.0321)	(0.0320)	(0.0320)
CG Index	-0.00423	-0.00398	-0.00385	-0.00377	-0.00402	-0.0192***	-0.0188***	-0.0184***	-0.0181***	-0.0189***
	(0.00422)	(0.00420)	(0.00421)	(0.00421)	(0.00420)	(0.00691)	(0.00690)	(0.00690)	(0.00687)	(0.00687)
FEM	0.0870	0.0951	0.0891	0.0966	0.0991	-0.279*	-0.255*	-0.277*	-0.237	-0.246*
	(0.0859)	(0.0853)	(0.0855)	(0.0854)	(0.0855)	(0.144)	(0.144)	(0.145)	(0.145)	(0.144)
TEN	0.0600***	0.0587***	0.0604***	0.0614***	0.0584***	-0.0136	-0.0181	-0.0119	-0.0119	-0.0188
	(0.0176)	(0.0176)	(0.0177)	(0.0177)	(0.0176)	(0.0233)	(0.0233)	(0.0232)	(0.0231)	(0.0232)
TQ t-1	-0.0460***	-0.0470***	-0.0468***	-0.0459***	-0.0467***	-0.215***	-0.217***	-0.216***	-0.214***	-0.216***
	(0.0125)	(0.0125)	(0.0125)	(0.0125)	(0.0125)	(0.0178)	(0.0177)	(0.0178)	(0.0178)	(0.0178)
Observations	9,579	9,579	9,579	9,579	9,579	9,632	9,632	9,632	9,632	9,632
R-squared	0.094	0.094	0.094	0.094	0.095	0.359	0.361	0.359	0.361	0.361
Number of firm	1,298	1,298	1,298	1,298	1,298	1,300	1,300	1,300	1,300	1,300
YEAR	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
FIXED EFFECTS	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Presents regression results for firm fixed effect regressions (*FE*) for a sample of Australian listed securities between 2001 and 2011. *DEG, CLO, BTW* and *EIG* denote the connectivity measure *Degree, Closeness*, *Betweenness* and *Eigenvector* defined at Equations (1), (2), (5) and (6) respectively, in Section 3.1 while *CONN* is a PCA factor generated from the four connectivity measures, *ROA_CY* is measured as earnings before interest, tax, depreciation and amortization (EBITDA) scaled by the book value of average total assets; *RET_CY* represents the annual total stock return measured at calendar year-end including dividends, both measured in the current year. *MV* represents firm size, the market capitalisation measured at fiscal year-end expressed in millions (common shares outstanding*closing stock price); *LEV* is firm leverage, long + short term debt/total assets; *AGE* is firm age, the number of prior years the firm appears in Thompson Reuters Datastream; *RISK* represents firm risk, the firm's stock return volatility, measured as the standard deviation of the previous calendar year's monthly stock return; *CG Index* represents the Harris (2008) corporate governance index score for the firm; *FEM* represents the ratio of female directors to board size; *TEN* is the average tenure of the board, measured by the total number of years served by all current directors on the board divided by board size; *TQ t-1* is a lagged dependent variable. *YEAR* and *INDUSTRY* are year and industry dummies respectively. Accounting and corporate governance data are collected at fiscal year-end in year *t.* Accounting and stock market data are obtained from Thomson Reuters Datastream. Corporate governance data are collected from Securities Industry Research Centre of Asia-Pacific (SIRCA) Corporate Governance Database. Standard errors are clustered by firm and presented in parentheses. * denotes significant at 10%, ** denotes significant at 5% and *** denotes significant at 1%.

Table 7.
Regression Results for Current Year Tobin's Q on Firm Connectivity Measures considering potential non-linearity

	TQ_CY	*TQ_CY*	*TQ_CY*	*TQ_CY*	*TQ_CY*	*TQ_t+1*	*TQ_t+1*	*TQ_t+1*	*TQ_t+1*	*TQ_t+1*
Constant	-1.338***	-1.351***	-1.350***	-1.349***	-1.350***	0.310**	0.301**	0.308**	0.312**	0.299**
	(-12.29)	(-12.38)	(-12.32)	(-12.42)	(-12.37)	(2.480)	(2.394)	(2.469)	(2.475)	(2.377)
DEG_lo	0.0181					0.0296				
	(1.138)					(1.494)				
DEG_hi	-0.0312*					-0.0205				
	(-1.844)					(-1.028)				
CLO_lo		0.0467***					0.0541***			
		(2.888)					(2.664)			
CLO_hi		-0.0361**					-0.0374*			
		(-2.189)					(-1.944)			
BTW_lo			0.0296*					0.0265		
			(1.909)					(1.436)		
BTW_hi			-0.0116					0.00561		
			(-0.833)					(0.338)		
EIG_lo				0.0454***					0.0358*	
				(2.987)					(1.898)	
EIG_hi				-0.0357**					-0.0543***	
				(-2.117)					(-2.882)	
CONN_lo					0.0430***					0.0550***
					(2.648)					(2.692)
CONN_hi					-0.0445***					-0.0361**
					(-2.888)					(-2.471)
MV	0.147***	0.148***	0.147***	0.148***	0.148***	0.00806	0.00936	0.00763	0.00881	0.00912
	(16.84)	(16.86)	(16.79)	(16.87)	(16.89)	(0.870)	(0.999)	(0.824)	(0.943)	(0.977)
LEV	0.334***	0.332***	0.331***	0.330***	0.332***	0.197***	0.196***	0.196***	0.196***	0.196***
	(6.185)	(6.173)	(6.140)	(6.136)	(6.172)	(3.387)	(3.404)	(3.371)	(3.390)	(3.393)
AGE	-0.0980***	-0.0985***	-0.0985***	-0.0985***	-0.0964***	-0.116**	-0.116**	-0.118**	-0.116**	-0.115**
	(-2.670)	(-2.686)	(-2.686)	(-2.686)	(-2.635)	(-2.441)	(-2.452)	(-2.489)	(-2.440)	(-2.431)
RISK	0.257***	0.256***	0.256***	0.256***	0.256***	0.162***	0.161***	0.162***	0.161***	0.161***
	(10.64)	(10.61)	(10.62)	(10.62)	(10.65)	(5.808)	(5.793)	(5.799)	(5.789)	(5.817)
CG Index	-0.0201***	-0.0199***	-0.0198***	-0.0198***	-0.0201***	-0.0143**	-0.0142**	-0.0141**	-0.0143**	-0.0143**
	(-3.765)	(-3.714)	(-3.713)	(-3.707)	(-3.769)	(-2.122)	(-2.111)	(-2.091)	(-2.120)	(-2.122)
FEM	0.0457	0.0567	0.0466	0.0681	0.0560	-0.0531	-0.0419	-0.0527	-0.0242	-0.0468
	(0.390)	(0.487)	(0.397)	(0.584)	(0.480)	(-0.389)	(-0.309)	(-0.387)	(-0.178)	(-0.344)
TEN	0.00622	0.00368	0.00545	0.00414	0.00337	0.0517**	0.0491**	0.0528**	0.0505**	0.0492**
	(0.325)	(0.193)	(0.284)	(0.217)	(0.176)	(2.174)	(2.071)	(2.217)	(2.136)	(2.072)
TQ t-1	0.346***	0.345***	0.345***	0.344***	0.344***	0.115***	0.114***	0.115***	0.114***	0.114***
	(22.91)	(22.80)	(22.86)	(22.83)	(22.83)	(7.179)	(7.087)	(7.161)	(7.088)	(7.105)
Observations	9,630	9,630	9,630	9,630	9,630	9,228	9,228	9,228	9,228	9,228
R-squared	0.349	0.350	0.349	0.350	0.350	0.139	0.140	0.138	0.140	0.140
Number of firm	1,297	1,297	1,297	1,297	1,297	1,259	1,259	1,259	1,259	1,259
YEAR	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
FIXED EFFECTS	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Presents regression results for firm fixed effect regressions (*FE*) for a sample of Australian listed securities between 2001 and 2011. *CY* indicates *DEG_hi*, *CLO_hi*, *BTW_hi* and *EIG_hi* and *CONN_hi* are the interaction between a dummy hi, defined as 1 if a firm-year connectivity score is in the top 25%, and the respective connectivity measure. *DEG_lo, CLO_lo, BTW_lo* and *EIG_lo* and *CONN_lo* are the interaction between a dummy lo, defined as 1 if a firm-year connectivity score is in the bottom 25%, and the respective connectivity measure. *TQ* is defined as total liabilities + preferred stock + market capitalisation (fye) + minority interests / total assets. *MV* represents firm size, the market capitalisation measured at fiscal year-end expressed in millions (common shares outstanding*closing stock price); *LEV* is firm leverage, long + short term debt/total assets; *AGE* is firm age, the number of prior years the firm appears in Thompson Reuters Datastream; *RISK* represents firm risk, the firm's stock return volatility, measured as the standard deviation of the previous calendar year's monthly stock return; *CG Index* represents the Harris (2008) corporate governance index score for the firm; *FEM* represents the ratio of female directors to board size; *TEN* is the average tenure of the board, measured by the total number of years served by all current directors on the board divided by board size; *TQ t-1* is a lagged dependent variable. *YEAR* and *INDUSTRY* are year and industry dummies respectively. Accounting and corporate governance data are collected at fiscal year-end in year *t*. Accounting and stock market data are obtained from Thomson Reuters Datastream. Corporate governance data are collected from Securities Industry Research Centre of Asia-Pacific (SIRCA) Corporate Governance Database. Standard errors are clustered by firm and presented in parentheses. * denotes significant at 10%, ** denotes significant at 5% and *** denotes significant at 1%.

Table 8.
Regression Results for Current Year Tobin's Q on Firm Connectivity Measures for the Main Component

	TQ_CY	*TQ_CY*	*TQ_CY*	*TQ_CY*	*TQ_CY*	*TQ_t+1*	*TQ_t+1*	*TQ_t+1*	*TQ_t+1*	*TQ_t+1*
Constant	-1.396***	-1.302***	-1.400***	-1.400***	-1.409***	0.202	0.306*	0.201	0.201	0.197
	(0.127)	(0.131)	(0.127)	(0.127)	(0.128)	(0.150)	(0.156)	(0.149)	(0.150)	(0.150)
DEG	-2.757					-0.226				
	(3.255)					(3.466)				
CLO		-0.823**					-0.887**			
		(0.341)					(0.417)			
BTW			-2.282*					-0.348		
			(1.258)					(1.394)		
EIG				-0.446***					-0.358*	
				(0.148)					(0.189)	
CONN					-0.0147**					-0.00774
					(0.00632)					(0.00684)
MV	0.152***	0.154***	0.153***	0.152***	0.153***	0.0242**	0.0266**	0.0243**	0.0245**	0.0250**
	(0.0105)	(0.0106)	(0.0105)	(0.0105)	(0.0106)	(0.0110)	(0.0111)	(0.0109)	(0.0110)	(0.0110)
LEV	0.132*	0.136*	0.131*	0.132*	0.132*	0.0736	0.0770	0.0733	0.0730	0.0731
	(0.0765)	(0.0766)	(0.0762)	(0.0764)	(0.0764)	(0.0740)	(0.0742)	(0.0740)	(0.0741)	(0.0740)
AGE	-0.103**	-0.102**	-0.106**	-0.108***	-0.103**	-0.111**	-0.106*	-0.111**	-0.112**	-0.109**
	(0.0418)	(0.0417)	(0.0416)	(0.0416)	(0.0417)	(0.0540)	(0.0542)	(0.0539)	(0.0539)	(0.0539)
RISK	0.227***	0.225***	0.227***	0.230***	0.227***	0.130***	0.128***	0.130***	0.132***	0.130***
	(0.0317)	(0.0317)	(0.0317)	(0.0317)	(0.0317)	(0.0382)	(0.0382)	(0.0383)	(0.0382)	(0.0382)
CG Index	-0.0152**	-0.0151**	-0.0150**	-0.0149**	-0.0152**	-0.0111	-0.0113	-0.0111	-0.0110	-0.0112
	(0.00654)	(0.00652)	(0.00651)	(0.00652)	(0.00652)	(0.00797)	(0.00798)	(0.00796)	(0.00796)	(0.00796)
FEM	-0.0676	-0.0528	-0.0620	-0.0465	-0.0550	-0.199	-0.181	-0.198	-0.182	-0.192
	(0.126)	(0.126)	(0.126)	(0.125)	(0.126)	(0.152)	(0.152)	(0.153)	(0.152)	(0.153)
TEN	0.0210	0.0197	0.0195	0.0203	0.0189	0.0365	0.0344	0.0362	0.0355	0.0352
	(0.0240)	(0.0240)	(0.0241)	(0.0239)	(0.0240)	(0.0296)	(0.0296)	(0.0297)	(0.0295)	(0.0296)
TQ t-1	0.313***	0.312***	0.312***	0.313***	0.312***	0.0648***	0.0644***	0.0647***	0.0652***	0.0647***
	(0.0185)	(0.0186)	(0.0186)	(0.0185)	(0.0186)	(0.0209)	(0.0209)	(0.0209)	(0.0209)	(0.0209)
Observations	6,699	6,699	6,699	6,699	6,699	6,412	6,412	6,412	6,412	6,412
R-squared	0.338	0.339	0.339	0.339	0.339	0.124	0.125	0.124	0.125	0.124
Number of firm	1,187	1,187	1,187	1,187	1,187	1,146	1,146	1,146	1,146	1,146
YEAR	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
FIXED EFFECTS	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Presents regression results for firm fixed effect regressions (*FE*) for a sample of Australian listed securities between 2001 and 2011 that are connected to the main network. *DEG*, *CLO*, *BTW* and *EIG* denote the connectivity measure *Degree*, *Closeness*, *Betweenness* and *Eigenvector* defined at Equations (1), (2), (5) and (6) respectively, in Section 3.1 while *CONN* is a PCA factor generated from the four connectivity measures, *TQ_CY* is defined as total liabilities + preferred stock + market capitalisation (fye) + minority interests / total assets in the current year, while *TQ_t+1* represents the next year Tobin's Q. *MV* represents firm size, the market capitalisation measured at fiscal year-end expressed in millions (common shares outstanding*closing stock price); *LEV* is firm leverage, long + short term debt/total assets; *AGE* is firm age, the number of prior years the firm appears in Thompson Reuters Datastream; *RISK* represents firm risk, the firm's stock return volatility, measured as the standard deviation of the previous calendar year's monthly stock return; *CG Index* represents the Harris (2008) corporate governance index score for the firm; *FEM* represents the ratio of female directors to board size; *TEN* is the average tenure of the board, measured by the total number of years served by all current directors on the board divided by board size; *TQ t-1* is a lagged dependent variable. *YEAR* and *INDUSTRY* are year and industry dummies respectively. Accounting and corporate governance data are collected at fiscal year-end in year *t*. Accounting and stock market data are obtained from Thomson Reuters Datastream. Corporate governance data are collected from Securities Industry Research Centre of Asia-Pacific (SIRCA) Corporate Governance Database. Standard errors are clustered by firm and presented in parentheses. * denotes significant at 10%, ** denotes significant at 5% and *** denotes significant at 1%.

Table 9.

Fama-MacBeth Regression Results for Current Year Tobin's Q on Firm Connectivity Measures

	TQ_CY	*TQ_CY*	*TQ_CY*	*TQ_CY*	*TQ_CY*	*TQ_t+1*	*TQ_t+1*	*TQ_t+1*	*TQ_t+1*	*TQ_t+1*
Constant	-0.449***	-0.408***	-0.417***	-0.436***	-0.490***	-0.0266	-0.0184	-0.00859	-0.00643	-0.0385
	(0.104)	(0.0947)	(0.0997)	(0.109)	(0.114)	(0.0659)	(0.0641)	(0.0670)	(0.0677)	(0.0734)
DEG	-9.944***					-3.375*				
	(2.215)					(1.675)				
CLO		-0.451***					-0.236***			
		(0.106)					(0.0708)			
BTW			-3.801***					-0.664		
			(1.192)					(1.451)		
EIG				-0.614**					-0.144	
				(0.230)					(0.237)	
CONN					-0.0219***					-0.00735**
					(0.00567)					(0.00374)
MV	0.0514***	0.0494***	0.0469***	0.0477***	0.0519***	0.0199***	0.0202***	0.0176***	0.0170**	0.0198**
	(0.00919)	(0.00855)	(0.00839)	(0.00928)	(0.00959)	(0.00586)	(0.00522)	(0.00544)	(0.00660)	(0.00633)
LEV	0.0549	0.0506	0.0546	0.0527	0.0542	0.0501	0.0492	0.0497	0.0480	0.0495
	(0.0587)	(0.0587)	(0.0581)	(0.0597)	(0.0589)	(0.0577)	(0.0581)	(0.0580)	(0.0582)	(0.0578)
AGE	-0.0352***	-0.0389***	-0.0384***	-0.0380***	-0.0352***	-0.0331***	-0.0341***	-0.0348***	-0.0354***	-0.0332***
	(0.0104)	(0.0107)	(0.0104)	(0.00979)	(0.0102)	(0.00915)	(0.00917)	(0.00948)	(0.00852)	(0.00915)
RISK	0.275***	0.269***	0.276***	0.277***	0.274***	0.216***	0.213***	0.215***	0.217***	0.215***
	(0.0464)	(0.0455)	(0.0467)	(0.0466)	(0.0459)	(0.0456)	(0.0449)	(0.0460)	(0.0454)	(0.0454)
CG Index	-0.00575	-0.00531	-0.00612*	-0.00646*	-0.00553	-0.00339	-0.00294	-0.00348	-0.00346	-0.00330
	(0.00326)	(0.00323)	(0.00337)	(0.00331)	(0.00329)	(0.00418)	(0.00416)	(0.00428)	(0.00414)	(0.00424)
FEM	-0.0975	-0.104	-0.110	-0.109*	-0.0902	-0.0427	-0.0418	-0.0479	-0.0625	-0.0430
	(0.0615)	(0.0612)	(0.0616)	(0.0578)	(0.0609)	(0.0893)	(0.0902)	(0.0905)	(0.0838)	(0.0873)
TEN	0.00304	0.00398	0.00556	0.00804	0.00291	0.00197	0.00140	0.00336	0.00492	0.00229
	(0.0131)	(0.0134)	(0.0126)	(0.0130)	(0.0129)	(0.0117)	(0.0119)	(0.0118)	(0.0122)	(0.0117)
TQ t-1	0.685***	0.686***	0.687***	0.687***	0.684***	0.529***	0.529***	0.530***	0.532***	0.529***
	(0.00747)	(0.00708)	(0.00668)	(0.00695)	(0.00752)	(0.00918)	(0.00889)	(0.00899)	(0.00897)	(0.00926)
Observations	9,630	9,630	9,630	9,630	9,630	9,228	9,228	9,228	9,228	9,228
R-squared	0.605	0.604	0.603	0.605	0.605	0.402	0.402	0.402	0.403	0.402
Number of groups	11	11	11	11	11	11	11	11	11	11
YEAR	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
INDUSTRY	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
FIXED EFFECTS	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Presents regression results for Fama-MacBeth regressions for a sample of Australian listed securities between 2001 and 2011 that are connected to the main network. *DEG, CLO, BTW* and *EIG* denote the connectivity measure *Degree*, *Closeness*, *Betweenness* and *Eigenvector* defined at Equations (1), (2), (5) and (6) respectively, in Section 3.1 while *CONN* is a PCA factor generated from the four connectivity measures, *TQ_CY* is defined as total liabilities + preferred stock + market capitalisation (fye) + minority interests / total assets in the current year, while *TQ_t+1* represents the next year Tobin's Q. *MV* represents firm size, the market capitalisation measured at fiscal year-end expressed in millions (common shares outstanding*closing stock price); *LEV* is firm leverage, long + short term debt/total assets; *AGE* is firm age, the number of prior years the firm appears in Thompson Reuters Datastream; *RISK* represents firm risk, the firm's stock return volatility, measured as the standard deviation of the previous calendar year's monthly stock return; *CG Index* represents the Harris (2008) corporate governance index score for the firm; *FEM* represents the ratio of female directors to board size; *TEN* is the average tenure of the board, measured by the total number of years served by all current directors on the board divided by board size; *TQ t-1* is a lagged dependent variable. *YEAR* and *INDUSTRY* are year and industry dummies respectively. Accounting and corporate governance data are collected at fiscal year-end in year *t.* Accounting and stock market data are obtained from Thomson Reuters Datastream. Corporate governance data are collected from Securities Industry Research Centre of Asia-Pacific (SIRCA) Corporate Governance Database. Standard errors are clustered by firm and presented in parentheses. * denotes significant at 10%, ** denotes significant at 5% and *** denotes significant at 1%.

Table 10.
Regression Results for Change in Current Year Tobin's Q on Change in Firm Connectivity Measures

	DEG	*CLO*	*BTW*	*EIG*	*CONN*
Constant	0.381***	0.00798***	0.000545***	0.0213***	0.381***
	(0.0443)	(0.00208)	(0.000188)	(0.00206)	(0.0443)
TQ_CY	-0.0259	-0.00218	-7.08e-05	0.000151	-0.0259
	(0.0273)	(0.00147)	(0.000124)	(0.000630)	(0.0273)
TQ t-1	0.00677	-0.000449	-9.60e-05	0.00161**	0.00677
	(0.0246)	(0.00130)	(0.000116)	(0.000769)	(0.0246)
MV	0.0373**	0.00243***	8.41e-05	0.000166	0.0373**
	(0.0159)	(0.000937)	(6.79e-05)	(0.000334)	(0.0159)
LEV	-0.000561	0.000340	-2.97e-05	0.000165	-0.000561
	(0.00659)	(0.000366)	(3.31e-05)	(0.000204)	(0.00659)
AGE	0.269***	0.00676	0.000860**	-0.00116	0.269***
	(0.0950)	(0.00501)	(0.000365)	(0.00271)	(0.0950)
RISK	0.0632*	0.00234	-1.63e-05	0.00442***	0.0632*
	(0.0376)	(0.00211)	(0.000170)	(0.000988)	(0.0376)
CG Index	-0.0159	-0.000557	-5.88e-05	7.90e-05	-0.0159
	(0.0103)	(0.000526)	(4.73e-05)	(0.000244)	(0.0103)
FEM	0.214	0.0104	-0.000299	0.00751	0.214
	(0.303)	(0.0162)	(0.00114)	(0.00832)	(0.303)
TEN	-0.329***	-0.0122***	-0.00101***	-0.00547***	-0.329***
	(0.0599)	(0.00272)	(0.000238)	(0.00152)	(0.0599)
Observations	8,256	8,256	8,256	8,256	8,256
R-squared	0.023	0.026	0.007	0.040	0.023
YEAR	YES	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES	YES

Presents regression results for regressions for a sample of Australian listed securities between 2001 and 2011 that are connected to the main network. *DEG*, *CLO*, *BTW* and *EIG* denote the change in the connectivity measure *Degree*, *Closeness*, *Betweenness* and *Eigenvector* defined at Equations (1), (2), (5) and (6) respectively, in Section 3.1 and *CONN* is a PCA factor generated from the four connectivity measures, *TQ_CY* is defined as the change total liabilities + preferred stock + market capitalisation (fye) + minority interests / total assets in the current year, while *TQ t-1* represents the change in the previous year's Tobin's Q. *MV* represents change in firm size, the market capitalisation measured at fiscal year-end expressed in millions (common shares outstanding*closing stock price); *LEV* is change in firm leverage, long + short term debt/total assets; *AGE* is firm age, the number of prior years the firm appears in Thompson Reuters Datastream; *RISK* represents change in firm risk, the firm's stock return volatility, measured as the standard deviation of the previous calendar year's monthly stock return; *CG Index* represents the Harris (2008) corporate governance index score for the firm; *FEM* represents the change in ratio of female directors to board size; *TEN* is the change in average tenure of the board, measured by the total number of years served by all current directors on the board divided by board size. *YEAR* and *INDUSTRY* are year and industry dummies respectively. Accounting and corporate governance data are collected at fiscal year-end in year *t*. Accounting and stock market data are obtained from Thomson Reuters Datastream. Corporate governance data are collected from Securities Industry Research Centre of Asia-Pacific (SIRCA) Corporate Governance Database. Standard errors are clustered by firm and presented in parentheses. * denotes significant at 10%, ** denotes significant at 5% and *** denotes significant at 1%.