

THE TECHNOSTRUCTURE GAP

The Educational Qualifications of Executive and Non-Executive Directors

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Word Count: 9,500

Key Words: Technostructure, CEO, Board of Directors, Education, Qualifications

JEL Codes: D82, G30, M20

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The Educational Qualifications of CEOs vis-à-vis Non-Executive Directors

ABSTRACT

The purpose of this paper is to investigate the educational qualifications and experience of executive and non-executive members of directorial boards in Australia. Inspired by Galbraith's (1967) analysis of the 'technostructure', we examine the educational qualifications of managerial (executive) directors and non-executive directors to assess the extent of divergences in the relevance (to the company's operations) of executives' and non-executives' educational qualifications. In addition, we measure the 'relatedness' of executives' and non-executives' educational qualifications to determine the extent to which the set of educational qualifications of executive directors diverges from that of non-executive directors. We find significant differences in the relevance of the educational qualifications possessed by executives and non-executives. We also find very low relatedness between the two sets of educational qualifications. The advantages of board diversity on the one hand and the disadvantages that may attend potentially sub-optimal technical information flow on the other are discussed.

The purpose of this paper is to present the results of an investigation into the educational qualifications (and experience) of Australian managers and the educational qualifications of Australian non-executive directors (members of boards). In particular, the investigation is focussed on the possession of educational qualifications and experience that are relevant to the technical information generated by particular types of business enterprise and the differences in such qualifications and experience that characterise managers, especially chief executive officers and managing directors, from those that characterise non-executive members of the board. The differences in qualifications are assessed and the 'relatedness' of the set of executive qualifications and the set of non-executive qualifications is measured. Any differences between managers and non-executives in this regard is potentially important since the ability to seek and interpret appropriate information is essential for the efficient operation of the modern corporation and the effective control or guidance of CEOs by boards of directors. Prior literature indicates that one of the key antecedents of non-executive directors' effectiveness is their level of knowledge and skills (Carter and Lorsch, 2004; Charan, 1998, Hendry, 2005). Indeed the management literature indicates that to be effective, non-executive directors should have both functional and firm-specific knowledge and skills (Carter and Lorsch, 2004, Charan, 1998). The optimality of the interaction between CEO and board may be subject to some diminution if the board of directors does not seek or is unable to effectively interpret and utilise the technical information provided to them by the CEO (even if the information is full and complete). Our results are relevant both to those studies that highlight the importance of board diversity and those that are concerned with the optimal flow of information to members of directorial boards.

In order to undertake an investigation of the educational qualifications of management and the qualifications of boards of directors, it is necessary to obtain a large amount of information about the management and boards of directors of a large number of Australian companies. The first formal part of this paper is devoted to reporting the results of an analysis of this data. Against particular criteria it is relatively straightforward to shed some light on the (technical) relevance of directors' educational qualifications. The second formal part of this paper is devoted to an analysis of the 'relatedness' of executive qualifications to non-executive board member qualifications. This analysis is designed to determine whether there are particular educational qualifications that occur more often than that which would be expected by chance occurrence among both executive and non-executive members of board of directors in Australian companies. This provides a formal analysis of where the differences in the possession of technically relevant *vis-à-vis* 'generalist' qualifications between management and boards of directors may lie but also generates important insights into the types of educational qualifications that dominate the leadership positions of Australian companies.

This paper is organised as follows. In Section II, a review of the literature is presented. The technostructure as originally discussed by Galbraith (1967) has not received a great deal of attention in the scientific economics literature. However, the effectiveness of board of directors has received much coverage in the related areas of strategic management, the theory of the firm and the research program broadly encompassed by the term ‘corporate governance.’ In Section III, the data is described. In Sections IV and V, the methodology deployed in this investigation is described and the results of the analysis are presented. There emerges from the analysis a clear indication that managers are far more likely to possess educational qualifications and experience that is relevant to the type of technical information generated by their business enterprise than non-executive members of boards of directors. Furthermore, the relatedness between the qualifications possessed by managers and the qualifications possessed by non-executive board members is quite low, particularly for the predominantly non-technical qualifications of Bachelor and Master of Arts which are held by many more non-executives than CEOs or managing directors. Section VI concludes the paper.

II. THE LITERATURE

The study of management and boards of directors is located at the intersection of three interlocking strands of scientific inquiry: (1) the theory of the firm; (2) strategic management and the economics of business strategy; and (3) corporate governance. The first of these deals with the reasons for the existence of firms. The second deals with the ways in which the firm makes the most out of its internal resources in its interactions with the external environment. The third deals with the variety of mechanisms that ensure (or attempt to ensure) that the suppliers of capital to a corporation obtain a return on their investment (Shleifer and Vishny 1997, p.737). Corporate governance as a field of inquiry both feeds into and draws upon the other two fields of inquiry. This is especially the case when the management and boards of directors are the subjects of analysis. As trustees of the firm’s resources, the managers of the firm direct those resources in particular ways. The ways in which they choose to direct resources depend on the strategies that they are deploying. The board of directors is one of the mechanisms for controlling and advising management and ensuring that decisions are made in accordance with shareholders’ interests. (Stiles and Taylor, 2001)

The separation of ownership and control, the documentation of which is attributed to Adolf Berle and Gardiner Means (Berle and Means 1930 and 1933; Means 1931), represents the cornerstone of modern inquiry into the governance of corporations. Berle and Means highlighted both the concentration of wealth within corporations and the dispersal of ownership among a multitude of small investors, each of whom had little power to compel a board of directors to control the corporation’s officers. This statistical data was utilised by Berle and Means to highlight the distinction between the modern corporation and the typical 19th century business enterprise. The conclusion that

“...there is no longer any certainty that a corporation will in fact be run primarily in the interests of the shareholders,” (Berle and Means 1933, p.293) demanded significant changes to the governance of these “quasi-public” institutions called corporations. The “traditional logic of property” no longer applies. Within the modern corporation, profits must be shared between the ‘owners’ and management in such a way that the latter has sufficient incentive to manage the firm’s resources efficiently. There is no longer an unbroken chain linking investment, decision-making and profit-taking.

Orthodox research in corporate governance is based upon the premise that various mechanisms are required in order to ensure that management acts in a manner that is likely to ensure appropriate levels of return for those who have supplied capital to the business enterprise. This is the agency perspective characterised by its focus on the separation of ownership and control. Essentially, how do investors get the managers of corporations to give them back their money? (Shleifer and Vishny 1997, p.738) Seeking the answer to this question has led researchers to traverse a large amount of legal and economic territory and solving the ‘agency problem’ is still the subject of much inquiry into the nature and effectiveness of incentive contracts, legal protection of investors, concentrated ownership (for example, ownership of large equity positions by fund managers) and market-based solutions (for example, the possibility of leveraged buy-outs). In most contributions to the corporate governance research, however, the board of directors is returned to again and again as a critically important mechanism for controlling management.

Boards of directors are mentioned in passing in most contributions to corporate governance research (see, for example, Jensen (1993) and Hart (1995)). But relative to the magnitude of the corporate governance literature, the *direct* scientific investigation of the characteristics of boards of directors constitutes a small component of the extant published material and more work has certainly been done in the areas of contract and agency costs. Exceptions to this include a number of scientific and more popular (non-academic) articles about various aspects of boards. For example, Magnet (1992) provides some interesting insights into board culture; *Economist* (2001) lists a number of interesting facts about non-executive directorial positions, including the relatively low remuneration that such positions attract and the increasing demands on the time of non-executive directors—due in large part to increasing involvement in tasks such as the formulation of business strategy; Murphy (1992), Jensen and Murphy (1990a and 1990b) and Core, Holthausen and Larcker (1999) highlight the relatively low ownership stakes that directors hold in the public companies on whose boards they serve; and Demb and Neubauer (1992), Jensen (1993) and Hermalin and Weisbach (1998; 2003) highlight the fact that CEOs may play a very active role in choosing members of the board.

In most of the extant research there is an underlying assumption that the board of directors exists to monitor the firm’s management and protect shareholder interests. Lorsch and MacIver (1989) and

Hermalin and Weisbach (1998; 2003) have examined this aspect of boards of directors by investigating how boards of directors monitor a Chief Executive Officer (CEO) and the frequency with which boards of directors have sought to actively replace an underperforming CEO. Whilst the results of such studies are interesting, boards of directors do not appear to closely monitor management and the replacement of a CEO by a board of directors is quite rare and is usually forced by the onset of some crisis (Jensen (1993), Weisbach (1988), Warner, Watts and Wruck (1989), DeAngelo (1988) and DeAngelo and DeAngelo (1989)). The main role played by boards of directors appears to be one of providing guidance and advice to the CEO (Fama and Jensen, 1983; Monks and Minnow, 1996). In either of these roles, the flow of information and the effectiveness with which it is interpreted are critical.

The flow of information to the board of directors has been investigated by financial economists and is the basis for some sophisticated theoretical models of the interaction of the CEO (or management) and the board of directors. Song and Thakor (2006) construct a theoretical model in which the board of directors performs the role of approving the CEO's proposals for projects under the constraint that the information available to the board is provided by the CEO. The interaction of the career concerns of both the CEO and the board are the key component of the model. The model generates interesting results that point to the possibility that boards may be ineffective even in the absence of the more prominent examples of inappropriate behaviour and conflicts of interest that are usually studied by corporate governance researchers. In a similar study, based in part upon the bargaining models of orthodox economic theory (see especially Crawford and Sobel (1982)), Adams and Ferreira (2007) examine the role of the board as both monitor of management and advisor to management. Again information plays a key role in the model and the results provide interesting insights into the interaction of the board and the CEO in a theoretical framework. In particular, the researchers conclude that management-friendly boards may be optimal where independent boards are not. The reason is that the CEO is less reluctant to share information with a friendly board.

Carter and Lorsch (2004) surveyed CEOs about the quality of the firm-specific knowledge of non-executive directors and found that most of the CEOs agreed that board members need a clear understanding of what drives the firm's strategic success. Without an intimate understanding of the company and its functioning, it is difficult for directors to deal with issues presented in the board meetings (Charan, 1998). Boards of directors constitute a resource on which managers may call for advice (Huse, 2005). Boards participate in the strategic decision-making process, support executive management in defining the strategic context of the firm, and provide external legitimacy and networking (Stiles and Taylor, 2001). At the strategic level, non-executive directors may be called on to participate in activities such as evaluating and selecting strategic alternatives that have been developed by senior managers, and providing advice to improve the quality of strategic decisions

(Huse, 2005; Styles and Taylor, 2001). Tricker (1997, p. 109) outlines the types of information about the external setting of the business needed by boards of directors for strategy formulation: “its customers and potential customers, competitors and potential competitors, all in the context of the economic, political, social and technological situation.”

An investigation of the educational qualifications of executive and non-executive members of boards of directors in Australian companies has implications for the formation of business strategy, the oversight and monitoring role of boards of directors and the relevance of information flows and the effectiveness of information interpretation. There are two possibilities. First, enhanced board diversity may be advantageous. Whilst previous research has not always focussed on diversity of educational qualifications, it is certainly possible that a wide range of backgrounds, including educational and experiential, may be beneficial (Dallas 2002). The restriction of board positions to individuals possessing particular demographic and educational credentials may only serve to sustain behaviours such as deferring to the CEO (Westphal and Stern 2006). On the other hand, enhanced diversity of educational qualifications may be disadvantageous if it introduces a sub-optimality into the flow and interpretation of information, particularly technical information, between management and non-executive directors. The present study prepares some of the groundwork for future investigations by presenting, with particular emphasis on technical relevance, an analysis of the educational qualifications of executives and non-executives in Australia.

III. DATA

The objective of this investigation is to examine in the Australian corporate environment the educational qualifications of management and non-executive members of boards of directors. To undertake the investigation, information concerning the educational qualifications held by the managers and boards of directors of Australian companies is necessary. Utilising the *Huntley's DataAnalysis* database as the principal source of data, the names, positions and educational qualifications of all executive and non-executive directors of the largest one hundred companies by market capitalisation (as indicated by the composition of the S&P/ASX100 index during January and February 2009) on the Australian Stock Exchange were collected. In the majority of cases, this data was supplemented with a review of the employment experience of these individuals. The data collection produced a detailed picture of the formal educational qualifications of the executive and non-executive directors and the ‘informal’ experience gathered by these individuals throughout their careers. An example for a single company is provided in Table 1.

INSERT TABLE 1 ABOUT HERE

The categories ‘technically relevant’ and ‘not technically relevant’ are defined as follows. The category ‘technically relevant’ refers to the possession of educational qualifications (or experience) likely to incorporate the technical knowledge required for a particular type of business. The category ‘not technically relevant’ refers to educational qualifications (or experience) unlikely to incorporate the technical knowledge required for a particular type of business. This is better explained by example. A mining corporation will generate a large amount of technical information concerning its operations. In general, the qualifications of an executive or non-executive director of such a business enterprise will be placed in the ‘technically relevant’ category if, for example, he or she possesses educational qualifications (or previously acquired experience) in fields such as materials science, engineering (chemical) or geology (this list is not exhaustive and particular educational qualifications and experience must be judged on a case by case basis). Conversely, the qualifications of an executive or non-executive director of such a business enterprise will be placed in the ‘not technically relevant’ category if, for example, he or she possesses other qualifications less relevant to the technical information characterising the firm’s operations. Such qualifications may include, for example, law, economics and finance (again, not an exhaustive list).

The task of allocating the qualifications (and experience) of almost 800 directors to one or the other of the broad categories ‘technically relevant’ and ‘not technically relevant’ is not straightforward and requires careful judgements to be made for almost every case. For this investigation, the task was completed in stages or ‘runs’. Each successive run through the list of executive and non-executive directors would lead to a more a satisfactory and justifiable allocation. Beginning with a ‘first order’ allocation based simply on the most obvious characteristics of an executive or non-executive director’s qualifications, the directors could be placed into one of the two categories (or designated with a question mark). For example, a Master of Science degree may be enough to warrant the allocation of a particular individual’s qualifications to the ‘technically relevant’ category, at least upon first inspection. A ‘second order’ allocation based on a more careful investigation of degree specialisation, for example, followed. Some individuals allocated a question mark in the first run would find a place in one of the two categories whilst others might be allocated to a different category than that in which they were placed in the first instance. The third and subsequent orders of allocation consisted of more and more refinement along these lines. The result is a carefully constructed and

justifiable allocation of executive and non-executive directors. A fraction of the directors were not allocated to either category but remained designated by a question mark¹.

Not surprisingly, some ambiguity remains. The qualifications of a number of individual directors (usually non-executives) were not able to be clearly allocated to either the technically relevant or not technically relevant categories. Most ambiguity is concentrated in the allocations of executive and non-executive directors of financial services firms such as insurance companies and property trusts. The ambiguity derives from the high numbers of executive and non-executive directors of such business enterprises possessing qualifications in economics, finance, accounting, management or financial planning either at the undergraduate level—possession of a Bachelor of Commerce being very common—or at the ‘post-graduate’ level—where the possession of a Master of Business Administration (MBA) is also very common. The allocation of many of the directors of financial services companies to either category on the basis of quite general educational qualifications and business experience is not free from ambiguity. Similarly, several companies have a conglomerate nature, thus making it difficult to align director qualifications with the business enterprise. For this reason, it was decided to eliminate 26 corporations from our final analysis.

The allocation process described in this section generated a picture of the educational qualifications (and experience) possessed by the executive and non-executive directors of the largest 100 Australian companies along with a catalogue of the categorisation to the categories of ‘technically relevant’ and ‘not technically relevant’ (and, in some, cases ‘undecided’). For each of the largest 100 companies listed on the Australian Stock Exchange, the final categorisation generated the following information: (1) total number of directors; (2) total executive directors; (3) executive directors with technically relevant qualifications; (4) executive directors without technically relevant qualifications; (5) executive directors with ‘undecided’ qualifications; (6) total non-executive directors; (7) non-executive directors with technically relevant qualifications; (8) non-executive directors without technically relevant qualifications; and (9) non-executive directors with ‘undecided’ qualifications. This categorisation together with the data concerning the educational qualifications of the executive and non-executive directors represents the base from which the formal part of the investigation is undertaken. The analysis of the data collected and organised in the manner described in this section focuses on the prevalence of technically relevant educational qualifications possessed by executive

¹ The complete allocation was undertaken by a qualified research assistant. To add another order of rigour to the allocation process, 20 companies were randomly selected and the allocation process undertaken independently by both of the authors. The average correlation of the allocations across the three independent allocations was 0.94.

and non-executive directors and the relatedness of particular educational qualifications between executive and non-executive members of board of directors.

IV. METHODOLOGY AND ANALYSIS

The first part of the formal analysis of the data is very straightforward. Quite simply, the data provide the basis from which to make comparisons concerning the prevalence of technically relevant educational qualifications qualified among executive directors (management) and non-executive directors. The first part of the formal analysis consists of this comparison. This represents some first steps towards a more complete understanding of the ‘technostructure gap’. The analysis is motivated, at least in part, by Galbraith’s (1967) analysis of the technostructure and the importance of technical information to the management of the modern corporation. This investigation is focussed on the technical expertise of management and non-executive members of the board of directors as revealed by their educational qualifications (and experience). These qualifications, which are a matter of the public record, may or may not align with the nature of technical information generated by particular types of business enterprise. It is the objective of the first part of this analysis to examine the prevalence of technically relevant educational qualifications among executive directors (management) and non-executive directors.

The first step of the analysis is to determine the number and percentage of managers (CEOs and managing directors) of the largest 100 companies in Australia that possess educational qualifications that align with the technical information generated by their business enterprise and compare this with the number and percentage of non-executive directors in possession of such educational qualifications (and experience). Following this, the more interesting cases are examined in more detail. The summary statistics of the data generated by the allocation process described in the previous section are presented below. For the largest 100 companies listed on the Australian Stock Exchange, there are 786 directors. Of these, 139 are executive directors (CEOs and managing directors) and 647 are non-executive directors. A summary of the results of the process of determining which of these directors possessed educational qualifications (and experience) relevant to the technical information generated by their particular corporations is presented in Table 2.

INSERT TABLE TWO ABOUT HERE

The first of the numbers shown in each row in Table 2 is for Australia’s largest 100 companies. The numbers in the final column are the results with the ambiguous cases removed. The majority of executive directors of the majority of Australia’s largest companies possess educational qualifications (and experience) that aligns with the technical information generated by their particular business

enterprise. However, it is evident that the same cannot be said for the non-executive directors who occupy places on the boards of Australia's largest companies. Approximately 68 percent of the executive directors (not including the 'ambiguous' cases) possessed formal qualifications (or experience) that aligns with the technical aspects of the businesses they manage. This compares to the possession of (recognisable) technically relevant educational qualifications by only 28 percent of the non-executive directors. This difference is substantial. On the average board of directors of Australia's largest companies, approximately 63 percent of non-executive directors possess non-technically relevant educational qualifications. This is in marked contrast to the overwhelming majority of CEOs and managing directors who do possess such qualifications and experience. None of the companies are characterised by boards of directors where all non-executive directors possess such qualifications and experience. Sixteen of the companies have no non-executive directors in possession of qualifications and experience that aligns with the technical information generated by their particular business enterprise.

In some ways, the most interesting cases revealed during the 'allocation' of executives to the 'technically relevant qualifications' and 'not technically relevant qualifications' categories are those companies that are operated by CEOs or managing directors who have no identifiable qualification or experience relevant to the technical aspects of their business enterprise. Approximately 70 percent of companies (or 18 of 26) managed by CEOs *not* in possession of the qualifications or experience necessary for them to be placed in the 'technically relevant qualifications' category are characterised by the presence of at least one non-executive director with 'technically relevant qualifications'. However, 98 percent of companies managed by CEOs who *are* in possession of the qualifications or experience necessary for them to be placed in the 'technically relevant qualifications' category are characterised by the presence of at least one non-executive director with 'technically relevant qualifications'. A CEO with a more technically relevant educational qualification is more likely to be complemented by at least one similarly qualified non-executive director whereas a CEO who is not in possession of a technically relevant educational qualification is not as likely to be complemented by non-executive directors in possession of such a qualification.

Once collected and organised—by allocating management and non-executive directors to the 'technically relevant qualifications' or 'not technically relevant qualifications' categories—the data reveals an illuminating picture of the possession by management of qualifications and experience that aligns with the technical aspects of their businesses relative to the possession of similar qualifications and experience by non-executive members of the board. The final allocations, even allowing for ambiguities, point so clearly to the presence of a 'technostructure gap' that it is difficult to find reason not to conclude that there is indeed a difference between the technically relevant educational qualifications possessed by the managers of Australia's largest companies relative to the technically

relevant educational qualifications possessed by non-executive directors of those companies. A strong motivation for this investigation was the possibility of finding evidence of the existence of Galbraith's (1967) technostructure within modern Australian corporations. There is certainly reason to believe that there is indeed a strong preponderance of CEOs who possess technically relevant educational qualifications *vis-à-vis* non-executive directors.

To further assess the differences in the prevalence of technically relevant educational qualifications among executive and non-executive board members, we conduct some further analysis on a company-by-company basis and determine a 'technostructure rating' for each company. For each of the 74 companies in our final sample, we first determine the proportion of executive and non-executive directors that hold technically relevant educational qualifications. Based on these proportions, including proportions of 'zero' for cases where there are no technically relevant qualifications are held by an executive and/or where there are technically relevant qualifications held by non-executive directors, we construct a 'Technostructure Rating' for each company. These ratings are described in further detail in Table 3.

INSERT TABLE THREE ABOUT HERE

Mean and median Technostructure Ratings are shown in Table 4, for the full sample and by industry. The energy and industrials sectors have the strongest ratings, while consumer staples and 'other' have the poorest. The 'other' category includes two telecommunications companies, one utilities company and one information technology company, all of which have a low technostructure rating. The mean and median proportion of executives and non-executive directors with technically relevant educational qualifications is also shown in Table 4. When the full sample is considered, the results support those presented previously on an individual director (director-by-director) basis. That is, the proportion of directors with technically relevant educational qualifications is significantly greater than the proportion of non-executive directors for our sample of large Australian companies. Both the Paired Samples T-Test and Wilcoxon Signed Ranks Test were used for this analysis, which lends further support to the hypothesis that there is a significant difference between the possession of technically relevant educational qualifications by managers and non-executive members of boards of directors.

INSERT TABLE FOUR ABOUT HERE

When industries are considered, the differences are more marked for some industries than others, with significant differences being observed for the energy, industrials, consumer staples, health care and materials industries. In all cases, the proportion of executive directors with technically relevant educational qualifications is greater than the proportion of technically qualified non-executive

directors. Some further interesting results that came to light when considering proportions of executive and non-executive directors holding technically relevant educational qualifications relate to the number of large Australian companies that do not have a single non-executive director with a technically relevant educational qualification, and particularly those that do not have an executive director with a technically relevant educational qualifications on their board. Approximately 22% (16) of boards do not have at least one non-executive director with technically relevant educational qualifications, while approximately 30% (22) of our sample of 74 boards do not have executive directors that possess technically relevant educational qualifications.

V. THE 'RELATEDNESS' OF EDUCATIONAL QUALIFICATIONS

In order to develop further insights into the difference in educational qualifications possessed by executive and non-executive directors, a measure of 'relatedness' was developed to determine in a very formal way the relatedness of particular educational qualifications across management (predominantly CEOs) and non-executive directors. For example, if a Bachelor of Laws degree is found to be common across both management and non-executive directors to an extent greater than that which would be produced by chance, this particular qualification will have a high relatedness score relative to an educational qualification that is less common across both management and non-executive directors. This measures the linkages that exist between the educational qualifications possessed by management and those possessed by non-executive directors throughout the sample of 785 directors. A low level of relatedness is expected for most educational qualifications because², on the basis of the analysis already undertaken and reported above, management is likely to hold a different set of educational qualifications and, indeed, a far more specialist set than the range of qualifications held by non-executives.

In order to construct a measure of relatedness for the educational qualifications possessed by the managers and non-executive directors contained in the sample, a measure of relatedness first utilised by Stigler (1968) and adapted by Teece, Rumelt, Dosi and Winter (1994) to measure relatedness of the industrial activities engaged in by American corporations was adapted to suit the purposes of this investigation. In fact, the measure utilised herein varies little from that developed by Teece *et al.* (1994) except for the completely different context in which the measure is deployed and the need to set up the measurement in the language appropriate for this investigation and not one aiming to determining relatedness of industry activities. With little or no change to the underlying nature of the statistical measure of relatedness developed by Teece *et al.* (1994) it is possible to utilise the measure to examine the relatedness of educational possessed by managers *vis-à-vis* non-executive directors. If

² This was written *before* the statistical measures of relatedness were calculated.

educational qualifications of a particular kind are possessed by managers as well as non-executive directors, the particular qualification has a high level of relatedness. If, however, a particular educational qualification is almost never held by both managers and non-executive directors, the particular qualification has a low level of relatedness. The measurement statistic has more power than simply determining which educational qualifications are most common among managers and non-executive directors. It allows the effect of chance to be ruled out and accounts for the fact that there are many more non-executive directors than CEOs.

Following Stigler (1968) and Teece *et al.* (1994) but with the appropriate change in language, notation and context, consider a universe of K educational qualifications possessed by M managers and D directors. Let $C_{mk} = 1$ if the educational qualification k is possessed by a manager (CEO or managing director) and 0 if otherwise. Likewise, let $C_{dk} = 1$ if the educational qualification k is possessed by a non-executive director. Now let J_{md} denote educational qualifications possessed by both managers m and non-executive directors d . The count of joint occurrences, Equation 1, is the basis for the measurement of relatedness of the educational qualifications possessed by management *vis-à-vis* those educational qualifications possessed by non-executive directors.

$$J_{md} = \sum_k C_{mk} C_{dk} \quad \text{(Equation 1)}$$

The measurement statistic emerges by considering J_{md} in comparison with the value for J_{md} that would be expected if educational qualifications were distributed randomly among executives. The objective is to compare J_{md} with the value for J_{md} that would be observed for a given number of managers, non-executives and educational qualifications if there were no relatedness at all or, equivalently, if educational qualifications were distributed randomly among all executives.

A sample (without replacement) of size n_m is drawn from the population of K educational qualifications and assigned to managers m . A second sample of size n_d is drawn from the population of educational qualifications and assigned to non-executive directors d . The number of educational qualifications held by both managers and non-executive directors is a hyper-geometric random variable:

$$\Pr[X_{md} = x] = f_{hg}(x, N, n_m, n_d) = \frac{\binom{n_m}{x} \binom{K - n_m}{n_d - x}}{K^{n_m}} \quad \text{(Equation 2)}$$

The expected number of commonly held educational qualifications among managers and non-executives if educational qualifications are assigned randomly is given by Equation 3. The variance is given by Equation 4.

$$\mu_{md} = E(X_{md}) = \frac{n_m n_d}{K} \quad \text{(Equation 3)}$$

$$\sigma_{md}^2 = \mu_{md} \left(1 - \frac{n_m}{K}\right) \left(1 - \frac{n_d}{K}\right) \frac{K}{K-1} \quad \text{(Equation 4)}$$

If the number of joint occurrences J_{md} greatly exceeds the expected number, there is a strong relatedness between managers and non-executive directors for the particular educational qualification. The measure of the relatedness of education qualifications possessed by managers (CEOs or managing directors) *vis-à-vis* non-executive members of the board of directors is then given by Equation 5 (Teece et al. 1994, pp.5-7).

$$t_{md} = \frac{J_{md} - \mu_{md}}{\sigma_{md}} \quad \text{(Equation 5)}$$

This statistic measures the degree to which the relatedness between CEO and non-executive qualifications exceeds that which would be expected if the educational qualifications were assigned randomly to CEOs and non-executive board members. The results generate insights into the qualifications that are most often the ‘common link’ between CEO educational qualifications and non-executive qualifications.

Using the dataset described in the previous section, the various educational qualifications held by both managers and non-executives—Bachelor of Commerce, Master of Engineering and so on—were listed. This provided a ‘universe’ of formal educational qualifications is distributed, in some fashion, among managers and non-executives. For each educational qualification a count was then made of the occurrences of each educational qualification among (1) managers, C_{mk} ; and (2) non-executives, C_{dk} . Following this, the process described above for computing the relatedness measure was

followed. The number of joint occurrences, J_{md} , the expected mean, μ_{md} and standard deviation, σ_{md} , were computed and the measure of relatedness calculated for each of the educational qualifications that exhibited joint occurrences. The measure of relatedness, Equation 5, ranged from 7.71 (for Bachelor of Arts) to 37.36 (for Doctor of Jurisprudence³). The average relatedness was 14.44 and the standard deviation of t_{md} was 7.90. A summary of the results are presented in Table 5 (which, of course, excludes those qualifications for which there were no joint occurrences).

INSERT TABLE FIVE ABOUT HERE

The most interesting features of the results are as follows. The lowest relatedness was exhibited by the educational qualification, 'Bachelor of Arts.' This is not surprising given the non-technical and non-specialist nature of most fields of inquiry that are grouped under the Bachelor of Arts category. Below-average relatedness was exhibited by the educational qualifications of 'Bachelor of Commerce,' 'Bachelor of Economics,' 'Master of Business Administration,' 'Bachelor of Science,' 'Doctor of Philosophy,' 'Master of Engineering' and 'Master of Arts.' Above-average relatedness was exhibited by the educational qualifications of 'Bachelor of Engineering,' 'Master of Science,' 'Doctor of Jurisprudence' and 'Bachelor of Business'. It should be noted, however, that there are relatively few holders of these four educational qualifications across the managers and non-executives of the 100 largest Australian companies.

Whilst a comparison with the average relatedness reveals some interesting results, it is desirable to determine whether the relatedness of the educational qualifications held by managers *vis-à-vis* non-executives is low or high. This can only be ascertained by comparing each of the measures in Table 5 with the measure that would have been recorded if there was a 1:1 ratio between managers and non-executives for each qualification. That is, with the relatedness measure that would result if there had been an equal number of managers and non-executives holding a particular qualification. This '1:1' relatedness measure must result in a relatedness measure that is the same for each educational qualification. For the data under consideration, the relatedness measure for each qualification for the '1:1' case is equal to 26.40. When the comparison between this '1:1' relatedness measure and the 'actual' measures are undertaken it becomes apparent that the relatedness measures presented in Table 7 are overall quite low. There is not a high level of relatedness between the educational qualifications held by managers and the educational qualifications held by non-executive members of the board of directors.

³ It must be noted that there were very few occurrences of the JD qualification but these were quite evenly spread between managers and non-executives.

Utilising the Huntley's *DatAnalysis* database (in conjunction with publicly available information), the educational qualifications and experience of the managers (CEOs and managing directors) of Australia's 100 largest companies were compared with the educational qualifications (and experience) of the non-executive members of the board of directors of those companies. The key objective was to determine whether there is a difference between managers and their boards with respect to possession of the educational qualifications relevant to the types of technical information generated by particular types of business enterprise. The main finding is that there is a considerably greater percentage of CEOs and managing directors in possession of such qualifications (and experience) than non-executive members of the board. The secondary finding is that there is relatively low relatedness between the qualifications possessed by managers *vis-à-vis* the qualifications possessed by non-executives. This is particularly the case for the Bachelor (and Master) of Arts educational qualifications, which are much more commonly held by non-executives than CEOs or managing directors.

VI. DISCUSSION AND CONCLUSIONS

In large part, this paper is motivated by Galbraith's (1967) contribution to the literature on the modern corporation and, in particular, his discussion of the technostructure. There is no 'technostructure literature' as such but the literature concerning the modern corporation is substantial. It is to this broader body of work that this paper contributes. The examination of the educational qualifications of managers and non-executive members of board of directors and the determination of whether these individuals possess identifiable educational qualifications and experience that aligns with the technical information generated by particular types of business enterprise represents some small steps towards a more complete understanding of the interaction of CEO, board of directors and information. The examination of the relatedness of the educational qualifications between managers and the educational qualifications possessed by non-executive members of the board generates further insights into characteristics that are likely to shape both the management of Australia's largest corporations and the dynamics of the day-to-day operations of these corporations.

The main findings of this investigation are as follows. First, a careful and considered allocation of managers and non-executives to the categories 'technically relevant qualifications' and 'not technically relevant qualifications' revealed that many more managers possess qualifications (and experience) that aligns with the technical information generated by their particular business enterprise than the non-executive members of the board of directors. Second, the formal statistical analysis of the relatedness of the educational qualifications of managers and the educational qualifications of non-executives revealed that the overall relatedness is low (compared with the relatedness measure

that would be recorded if each educational qualification was held by managers and non-executives in equal number) and the relatedness measures for particular non-technical (or non-specialist) qualifications that are predominant among non-executives, especially Arts qualifications, are lower than the average. Many of the specialist qualifications that also recorded low relatedness measures were held in much greater proportions by managers than non-executives. The relatedness measure does not consider the 'major' or 'specialisation' of a degree program and does not, therefore, cover exactly the same ground as the allocations of managers and non-executives to 'technically relevant qualifications' and 'not technically relevant qualifications' categories but the finding of low relatedness (overall) and the low relatedness of particular educational qualifications certainly does not contradict the first finding generated by this investigation (that managers are much more likely to possess qualifications relevant to the technical information generated by their business enterprise than non-executives).

The difference between managers and non-executives with regard to educational qualifications relevant to the technical information generated by their business enterprise and the low level of relatedness of the educational qualifications of managers and the educational qualifications of non-executives is potentially important for several reasons. First, the ability to seek and interpret appropriate information is essential for the efficient operation of the modern corporation and the effective control or guidance of CEOs by boards of directors. The optimality of the interaction between CEO and board may be subject to some diminution if the board of directors does not seek or is unable to effectively interpret and utilise the technical information provided to them by the CEO (even if the information is full and complete). Second, the neoclassical utility functions that would be utilised to describe the interaction of managers, non-executives and shareholders in the context of a modern corporation may not be completely reconcilable if the maximisation problems are solved in the presence of divergences of technical understanding. In a formal model of the interaction of CEO and non-executives, sub-optimality deriving from the inefficient interpretation of technical information may emerge even if information flows between CEO and non-executives are complete.

When asked, managers of divisions of major corporations (example, sales, finance, manufacturing) identified the 'most serious problem facing the firm' as one which lay in the domain of his or her own area: sales problems for sales executives, finance problems for finance executives, manufacturing problems for manufacturing executives (Dearborn and Simon 1958, quoted in Simon (1991, p.37)). The results of the present investigation provide reason to suspect the possibility of another dimension to this observed behaviour. Leaving aside the obvious and analogous possibility that the CEO may view the most serious problems facing his or her firm as ones that derive from particular technical aspects of the operation of the modern corporation, a more significant problem is that it is possible that the CEO provides the information to the board of directors that he or she views as most

important. But the decision regarding the importance of which information to provide is made by applying the filter of his or her technical knowledge. Like Dearborn and Simon's executives, our CEOs may be inclined to view particular types of technical reports as more important: for the financial economist CEO, economic reports; for the chemical engineer CEO, laboratory or field reports; and so on. The further investigation of this is a tantalising prospect for future research.

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Table 1 Example of a Typical Company Overview

Code: AMC GICS: Materials	Name	Position	Educational Qualification
	Chris I Roberts	Chairman of Board NE 2000	B.Com
	Ken N Mackenzie	CEO, M. Director 2005	BEng, FIEA
	Don Matthews	CEO (Acting) Australasia 2008	Dip Teaching
	Stephen Dunne	M. Director 2004	CFA, B.Bus (Mgt & Mktg), MBA, ASIA
	R Keith Barton	Director NE 1999	BSc, PhD, FTSE, FAICD
	G John Pizzey	Director NE 2003	BE (Chem), Dip. Mgt. FTSE.
	Ern JJ Pope	Director NE 2005	BSc
	John G Thorn	Director NE 2004	FCA
	Geoff Tomlinson	Director NE 1999	BEcon.

Table 2 Executive and Non-Executive Directors classified according to whether they hold ‘Technically relevant’ educational qualifications

	S&P/ASX100	Sample for Analysis (74)
Total Number of Directors	786	563
Total Executive Directors	139	99
Executive Directors with ‘Undecided’ qualifications	29	7
Executive Directors without ‘Technically relevant’ qualifications	28	24
Executive Directors with ‘Technically relevant’ qualifications	82	68
Total Non-Executive Directors	647	464
Non-Executive Directors with ‘Undecided’ qualifications	145	44
Non-Executive Directors without ‘Technically relevant’ qualifications	341	292
Non-Executive Directors with ‘Technically relevant’ qualifications	161	128

Table 3 Technostructure Rating Scale

Rating	Descriptor	Measurement
1	Poor	No technically relevant qualifications held by non-executive directors.
2	Potentially problematic	At least one non-exec with a technically relevant educational qualification but no executive with technically relevant qualifications on the board.
3	Sound	At least one executive director with a technically relevant educational qualification and one non-executive director with a technically relevant educational qualification, but a greater proportion of executives hold technically relevant educational qualifications ($\geq 40\%$ difference in proportions qualified).
4	Strong	At least one executive director with a technically relevant educational qualification and one non-executive director with a technically relevant educational qualification, and similar proportions of executives and non-executives holding technically relevant educational qualifications ($< 40\%$ difference in proportions qualified).

Table 4 Mean (and Median) Technostructure Ratings and Proportions of Directors with Technically Relevant Qualifications

Industry	Number of Companies	Technostructure Rating	Proportion Technically Relevant		Tests of difference
			Executive	Non-Executive	
All	74	2.460 (3.000)	0.644 (1.00)	0.270 (0.270)	t = 6.896*** Z = -5.626***
Consumer Discretionary	6	2.333 (2.000)	0.555 (0.500)	0.195 (0.085)	t = 1.899 Z = -1.625
Consumer Staples	6	1.833 (1.500)	0.667 (1.000)	0.088 (0.070)	t = 2.557* Z = -1.769*
Energy	12	2.917 (3.000)	0.833 (1.000)	0.331 (0.310)	t = 4.489** Z = -2.827**
Financials	12	2.667 (3.000)	0.667 (1.000)	0.413 (0.415)	t = 1.685 Z = 1.610
Health care	5	2.200 (3.000)	0.734 (1.000)	0.256 (0.380)	t = 3.897** Z = -1.826*
Industrials	12	2.750 (3.000)	0.625 (1.000)	0.256 (0.210)	t = 2.991** Z = -2.278**
Materials	17	2.412 (3.000)	0.539 (0.670)	0.287 (0.290)	t = 2.032* Z = -1.979*
Other	4	1.250 (1.000)	0.500 (0.500)	0.035 (0.000)	t = 1.499 Z = -1.089

*** significant at < 0.001 , **significant at < 0.01 , * significant at < 0.10 , two-tailed

Table 5 The Relatedness of Educational Qualifications: Management *vis-à-vis* Non-Executives

Educational Qualification	Measure of Relatedness
Bachelor of Commerce	12.5683065
Bachelor of Economics	9.57953924
Bachelor of Engineering	17.9304466
MBA	13.0461103
Bachelor of Science	12.6341695
PhD	9.14914546
Master of Engineering	12.1240759
Bachelor of Arts	7.71185709
Master of Arts	9.09531459
Master of Science	17.536988
JD	37.3631218
Bachelor of Business	14.5492384