Pyramidal Structure, Top Executives' Within-Group Engagements, and Corporate Innovation

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Abstract

We examine how pyramidal group structure and top executives' concurrent engagements within group affect innovation of listed firms in China. Our results show that listed firms in lower levels of group pyramid are less innovative, measured in terms of R&D expense and patent applications. Further analysis shows that the negative impact is unrelated the ultimate shareholders' incentives to tunnel resources from bottom-level firms. Besides, a firm becomes less innovative when its CEO or board chair concurrently takes an upstream position, i.e. a position in an upper-level firm in group, while it becomes more innovative when its CEO or board chair concurrently takes a downstream position, i.e. a position in a subsidiary or an affiliated company. Those upstream positions, nevertheless, enhance corporate innovation when they are located at low levels of pyramid. Our results indicate that in China, corporate pyramids deter innovation of low-level firms in group, but the problem is partially resolved by having CEO or board chair engaging in upper-level firms.

1. Introduction

In emerging markets, many businesses are organized in group rather than operated on a stand-alone basis. Specifically, the pyramid structure of business group is common in many East Asian countries (Claessens et al 2002) including China (Fan et al 2013). A well-understood benefit of a pyramid structure is that it allows members to share resources, thereby reducing their financial constraints (Almeida and Wolfenzon 2006; Almeida et al. 2011) and facilitating investments (Masulis et al. 2011; Buchuk et al. 2014). This is particularly important when financial markets are under-developed and external financing is costly. Other benefits of a pyramidal group structure include limited liability to parent firm (Khanna and Yafeh 2007) and shielding state-owned businesses from political interferences (Fan et al. 2013).

On the other hand, a pyramidal group structure results in a large wedge between control right and cash flow right of listed firms at the bottom level, which creates incentives for the controlling shareholder to expropriate minority shareholders of those listed firms (Claessens et al 2002). Besides, the multi-layer structure also creates information barriers between the top and the bottom of the pyramid, which may cause bottom-level firms to deviate from the group interest.

Against this background, this study aims to examine economic implications of corporate pyramidal structure in China in two dimensions. The first dimension is the impact of group affiliation on corporate innovation in China. We examine corporate innovation because it has become a hot issue for academic research in recent years, especially on top academic journals (He and Tian 2018). Moreover, a country's innovation activity plays an important role for its economy development.[1] Corporate innovation plays an important economic role in China as

[1] For instance, OECD reports that even though there are different phases of economy cycle for countries around the world, innovation accounts for approximately 50% of GDP growth. Chang et al. (2018) find that one standard deviation of patent stock increase is associated with a 1.58% elevation in GDP growth and 1.52% elevation in total factor productivity (TFP) growth.

well. China has become one of the most important power engines in innovation. According to World Intellectual Property Indicators, China overtook the US in terms of the number of patent filings in 2011.

Corporate pyramidal structure may have positive or negative impact on innovation of listed firms in group. On one hand, the pyramidal structure shield firms from political interference (Fan et al 2013; Opie et al 2019), which may give more discretion for managers to innovate. In their theoretical study, Dutta and Fan (2012) examine how centralized and delegated forms of investment decision process affects divisional managers' incentives to innovate. In their model, division managers face the risk being taken away their innovation by the headquarters and the hold-up problem is more severe under the centralized investment structure than under the delegated one. Along this line of arguments, listed firms at lower levels of group pyramid should be more innovative because they have more delegated power.

On the other hand, the pyramidal structure allows the ultimate parent to maintain significant control right while keeping little cash-flow right in listed firms at the bottom of group pyramid (Claessens et al 2002). This creates incentives for the ultimate parent to expropriate minority shareholders of those bottom-level firms. Moreover, the ultimate parent may allocate fewer investment opportunities to bottom-level firms when it cannot obtain sufficient information from them. Therefore, we expect if innovation projects are value-enhancing in general, then the ultimate parent should retain more innovation activity at upper-level firms and therefore lower-level firms should have less innovation input and outcome.

The second dimension of our research focus is to examine the impact of a specific feature of business groups in China – top executives taking concurrent positions in different firms within group, on innovation. Owing to data limitation, empirical studies about concurrent positions taken by top managers within group are scant, except Khanna and Thomas (2009) showing that common directors result in more synchronized stock returns in Chile. For the purpose of our study, we use a novel dataset that provides information about concurrent outside positions taken by top executives and directors of listed firms in China. In China, it is very common for a firm's top executives to serve other companies or organizations concurrently. In our sample period in 2007-2015, 47.4% of senior managers, including chief executive officers (CEOs), board chair, and other senior executives, engage in at least one positions outside their employers. Among those outside positions, 19.3% of them are positions in upper-level firms and 19.6% of them are positions in lower-level firms within business group.

These within-group engagements may be detrimental to or enhancing firm performance. On one hand, they facilitate information exchange between member firms. Early evidence on information sharing among firms via common agents is provided by Khanna and Thomas (2009) who find that firms that share common directors have more synchronous stock returns controlling for ownership overlap. More recently, Renneboog and Zhao (2014) find that firms with common directors are more likely to merge and these mergers tend to have a higher completion rate and take a shorter time to complete than other mergers. Therefore, common agents within group could enhance resources allocation among group members.

On the other hand, these within-group engagements may distort top executives' incentives in decision making. Conflicts of interests of common agents are widely documented in studies on investment banking that key product-market rivals tend to avoid sharing same financial advisor (Asker and Ljungavist 2010) and a financial advisor generally leans toward the bidder when it maintains relationship with both parties of merger (Agrawal et al 2013; Chang et al 2016). For our study, two negative consequences may arise when top executive are serving both an upper-level firm and a lower-level firm within group. First, top executives may have more opportunities to help the ultimate parent to tunnel resources from the lower-level firm. Moreover, top executives may bias for the upper-level firm in key decisions because they have more resources under control at the upper-level firms than at the lower-level firm.

Furthermore, even managerial decisions are unbiased, if these "outside" positions are important and time-consuming, then managers' attention to the listed firm will be diverted and the firm's performance will be affected. This argument is supported by previous studies on busy directors that although directors' social networks enhance M&A decision (Cai and Sevilir 2012) and corporate innovation (Faleye et al 2014), too many engagements compromise their time to fulfill their monitoring role (Fich and Shivdasani 2006; Hauser 2018).

Our study uses a sample of A-share listed firms in China in 2007-2015 to examine (1) whether listed firms in lower levels of group pyramid have more or less innovation; and (2) whether top executives' engagements in other companies within group result in more or less innovation. Following previous studies (Acs and Audretsch, 1988; Barker and Mueller, 2002; Meliciani, 2000; Hirshleifer et al., 2012), we measure corporate innovation by both innovation input and innovation outcome. Innovation input is measured as 100 times research and development expense scaled by total assets, and innovation outcome is defined as patent applications per 100-employee. Besides, for each company we identify its group companies in upper levels and lower levels of group pyramid. An upper-level firm is a listed or non-listed entity that is controlled by the ultimate parent and has ownership in the firm in concern, while a lower-level firm is a subsidiary or affiliated firm of the firm in concern.

To examine the impact of key executives' outside positions on firm's innovation, we create indicators for different types of positions engaged by the CEO and the board chair. Specifically, for each listed firm, we classify its CEO's and board chair's outside positions into (i) positions in upper-level firms within group under the ultimate shareholder (upstream positions thereafter), (ii) positions in lower-level firms within group (downstream positions thereafter), and (iii) positions in other firms/organizations. We consider only the CEO but not other top executives because the importance of CEO on innovation is highlighted by recent studies as summarized by He and Tian (2018).[2] Therefore, among top executives, we expect the CEO's outside positions have stronger impact on corporate innovation than other top executives'. Moreover, as previous studies suggest that corporate board chairs work full time in China and board chairs rather than CEOs are real bosses in China's listed firms (Jiang and Kim, 2015; Kato and Long, 2006), we consider the impact of board chair's outside positions on corporate innovation in our analysis as well.

Our baseline result shows that firms in a lower level of group pyramid have less innovation input and output (Table 2). On the other hand, the divergence between control right and cash flow has insignificant impact on innovation input and output (Table 3). Therefore, our result suggests the pyramidal corporate structure causes firms at lower levels of pyramid less innovative but tunneling is unlikely to be the main cause of the effect.

Then, we examine whether engagements of top executives (CEO and board chair) in within-group positions enhances or deters their employers' innovation activity (Table 4). Our result indicates that engagements in upstream positions result in less innovation while engagements in downstream positions results in more innovation. Positions in other firms/organizations have insignificant impact on innovation. Therefore, a firm's top executives' engagements in within-group positions may have enhancement or detrimental effects on the firm's innovation, depending on levels of those positions within group. In particular, that engagements in upstream positions are detrimental to innovation is consistent with the entrenchment argument that top executives value more their positions in an upper-level firm than those in a lower-level firms. On the other hand, our finding is inconsistent with the busyness argument because engagements in downstream positions are found to enhance innovation.

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[2] Specifically, previous studies document that various CEO attributes such CEO experience (Custodio et al., 2019; Islam and Zein, 2019; Yuan and Wen, 2018), personal character (Hirshleifer et al., 2012; Sunder et al., 2017), and compensation (Mao and Zhang, 2018; Blank and Goldie, 2019) affect corporate innovation.

In our further analysis, we interact variables for various concurrent positions with the layer of firm in group pyramid, and re-run our regressions. The result indicates that while engagements in upstream positions are detrimental to innovation, its detrimental effect is weaker down the group (Table 5). At the very low level of corporate pyramid, engagements in upstream positions even enhance innovation. We argue that when a group firm is very far away from the vertex of pyramid, engagements of its top executives in upstream positions can narrow down information gap between the top and the bottom, which makes more innovation projects available to the firm.

To confirm the robustness of our findings, we conduct a battery of tests including treatment-effect model (Table 6), propensity-score matching (PSM) analysis (Table 7), and sub-sample analysis (Table 8). All results confirm that firms with top executives taking upstream positions are less innovative when those firms are close the ultimate parent but more innovative when those firms are far away from the ultimate parent. Besides, our results indicate that those positions have different impacts on innovation of SOEs and non-SOEs but nevertheless importance for innovation of all listed firms in China.

Our study contributes to the literature in three ways. First, it sheds light on the literature of costs and benefits of pyramidal group structure particularly in China. Previous studies on this topic mainly focus on the ultimate shareholders' incentives to tunnel due to divergence in control and cash-flow rights created by the pyramid structure. Our findings, on the other hand, indicate that the detrimental effect of corporate pyramid could also come from top executives' assessment on relative importance of their concurrent positions within group. Our study has potential implications and significance for other studies that examine the impact of group pyramid on firm performance and decisions.

Second, our study complements recent studies focusing on SOEs in China by Fan et al (2013) and Opie et al (2019) that the pyramidal group structure creates value by shielding SOEs' managers from the state interference. Our findings demonstrate that corporate pyramid affects innovation of both SOEs and non-SOEs but the detrimental effect can be alleviated by having top executives taking a position at an upper-level firms within group. Therefore, group pyramid affects non-SOEs' performance as well.

Third, the study contributes to the literature on CEO characteristics and innovation by showing when CEO's experience could deter firm's innovation. A recent work by Custodio et al (2019) shows that CEO's general managerial skills enhance innovation, with general managerial skills measured based on the CEO's work experience in different industries and types of position. Our study, however, suggests that not all CEO's connections spurs innovation. Rather, CEOs may exploit their connections within group for private concerns and interests. Nevertheless, we also show that a firm's CEO connections within group are beneficial for innovation when the firm is very far away from the vertex of pyramid.

The rest of the paper is organized as follows. Section 2 presents methodology and data. Section 3 describes and discusses major empirical findings and robustness checks. Section 4 concludes the study.

2. Data and Methodology

2.1 Sample

The initial sample contains all Chinese A-share listed companies on Shanghai and Shenzhen Stock Exchange during the period of 2007 to 2015. Our sample starts in year 2007 because it is the first year R&D data is available. Firms' financial information and board information are collected from CSMAR database. Control chain diagrams for identifying upper-level companies and the ultimate parent in group come from China Corporate Governance Analysis Database provided by Taiwan Economic Journal (TEJ). Financial firms and observations with missing values for regression variables are omitted. All continuous variables are winsorized at 1st and 99th percentiles to alleviate the effect of outliers. Our final sample contains 17,331 firm-year observations for baseline regressions. As both R&D expense and patent applications are bounded below at zero, an OLS model may result in biased estimation of coefficients. Therefore, we estimate our models using a Tobit regression as well. Table 1 describes the statistics summary. The definitions of all variables are available in Appendix A.

2.2 Measurements of innovation

We measure innovation based on both inputs and outputs. Research and development is one of the major components of inputs for innovation and it is also one of the most fundamental investment decisions made by top executives of firms (Barker and Mueller, 2002). For our study, we define innovation input as 100 times R&D expense scaled by total assets. On the output side, patents are the most important outcomes of corporate innovation because they indicate the success of innovation and they provide their holders an exclusive right of using designated technologies for producing and selling products/services within a fixed period of time. Therefore, we define innovation output as 100 times the number of patent applications scaled by total employees. We collect the number of patent applications variable from the CSMAR Listed Firm's Patent database. The database covers both patent applications and parent grants by year but we measure innovation by the patent applications each year because it usually takes from months to years for a firm to get a patent grant after making an application. Therefore, the number of patent applications is better than the number of patent grants as a proxy for innovation outcomes in a particular year. Theoretically, we should weigh patents by their quality in the construction of variable for innovation outcomes. However, as there is no citation information in China's parent database, we can only use the total number of patent applications as a measure of innovation output for our analysis.

2.3 Information on outside positions of top executives

For our sample listed firms, we collect information on outside positions taken by their top executives from CSMAR Corporate Governance database. For each outside position, CSMAR provides information on firm name and the level of position. From the initial dataset, we classify those positions into two groups: positions in upper-level companies controlled by the same ultimate shareholders, and other external positions. Positions in the first group are identified by comparing firm names of outside positions with firm names in control chain diagrams provided by the TEJ. TEJ control chain diagrams are organized on firm-year basis and each control chain diagram contains the name of all upper-level companies for a listed firm in a year. Other external positions, i.e. unmatched outside positions, are then further classified into two sub-groups, namely (1) positions in lower-level affiliated companies or subsidiaries, and (2) positions in other companies/organizations. Positions in the first sub-group are identified by comparing firm names of external positions with the list of affiliated companies and subsidiaries. The second sub-group is a residual group.

2.4 Baseline Model

We examine the relation between top executives' external engagements and corporate innovation using both OLS and Tobit regressions. Following Chang et al. (2015) and Hirshleifer et al. (2012), the baseline empirical model is defined as follows:

$$INNOVATION_{it} = \alpha + \beta KEYIND_{it} + \gamma X_{it} + \delta INDUSTRY_i + \theta YEAR_t + \varepsilon_{it} \quad (1)$$

where $INNOVATION_{it}$ is corporate innovation input activities, measured as 100 times research and development expenditure scaled by total assets, and 100 times patent applications scaled by total employees. $KEYIND_{it}$ is the set of key independent variables including (1) level of firm in group pyramid, (2) the wedge between control right and cash-flow right of the ultimate shareholder as given by the TEJ, and (3) indicators for different types of top executives' external positions. X_{it} is a set of control variables. Industry- and year-fixed effects are included.

3. Results

3.1 Descriptive statistics

Table 1 reports summary statistics of key variables for regression analysis. The section for key independent variables shows that the median firm is located in the third level of group pyramid, i.e. two levels from the ultimate parent (level 1). On average, the ultimate parent holds a control right that is 33.7% larger than its cash-flow right. 57.2% of listed firms have their top executives, i.e. CEOs or board chairs, working for at least one upper-level company controlled by the same ultimate shareholder. This suggests that in China, it is a common practice for ultimate shareholders to send a representative to take a key position in their listed subsidiaries. The statistics also show that about one-thirds of listed companies have the top executives also working in an affiliated company or a subsidiary. Again, this suggests that business groups in China frequently control the group companies by interlocked management. Surprisingly, it is also very common for a listed firm's top executives (about 47.4% of them) to work for other firms or organizations. A brief check of those positions indicates that those positions vary largely in nature.

[Insert Table 1]

3.2 Main empirical results

Table 2 reports results from regressions of innovation on listed firm's position in group (*Level in group*) together with other control variables. Innovation is proxied by either (1) 100 times R&D expense scaled by total assets or (2) 100 times the number of patent applications scaled by total employees. The former proxy measures the innovation input while the latter measures the innovation outcome. Moreover, as both R&D expense and patent applications are bounded below at zero, an OLS model may result in biased coefficients. As a result, we also estimate our models using a Tobit regression.

Columns 1 & 2 report regression results for R&D expense. The coefficient for *Level in group* is negative and significant at the 1% level. As a larger value of *Level in group* suggests that the listed firm is further away from the ultimate parent, the negative coefficient for this variable indicates that firms at bottom levels are less innovative. From column 2, the economic significance is such that a one-level away from the ultimate parent results in a 14.5% reduction (=0.149/1.031) in innovation input from the sample mean. A similar finding is obtained from regressions for patent applications in columns 3 & 4. From column 4, a one-level away from the ultimate parent results in a 15.1% reduction (=0.146/0.965) in innovation input from the sample mean.

[Insert Table 2]

As discussed in the introduction, listed firms at lower levels of group pyramid are less innovative for two reasons. First, the ultimate parent has strong incentives to tunnel resources from those firms because it has little cash-flow right while maintaining significant control rights. When it has good investment opportunities, it is more likely allocate those opportunities to upper-level firms than to lower-level firms. Second, the information gap between those firms and the ultimate parent is large because they are far apart. As information is particularly relevant for allocation of projects with high risk and large information asymmetry, such as innovation projects, a large information gap deters the ultimate parent from allocating innovation projects to those firms.

To distinguish between the two driving forces behind the impact of listed firm's position in group on innovation. We replace *Level in group* by *Control right*/*Cashflow right* that captures the ultimate shareholders' incentives to tunnel.[3] In general, a larger wedge between control right and cash-flow right suggests a stronger incentive for ultimate shareholders to tunnel. Therefore, we expect a negative coefficient for *Control right*/*Cashflow right* if the impact of listed firm's position in group on innovation is driven by the ultimate shareholders' incentives to tunnel.

Table 3 reports the result. It indicates that the divergence in control right and cash flow right has statistically insignificant impact on both innovation input and innovation output. Therefore, the result is inconsistent with the tunneling argument that firms at a lower level in group are less innovative because of the ultimate shareholder's incentive to tunnel resources from those lower-level firms. Rather, the information gap between those firms and the ultimate parent is a more possible cause for low innovation activity of those firms.

[Insert Table 3]

Table 4 reports results from regressions of innovation on indicators of various top executives' external positions together with other control variables. Key independent variables include (1) an indicator that equals one if firm's top executives (CEO or board chair) work for at least one upper-level company controlled by the ultimate shareholder (*Position in upper-level firm*), (2) positions in affiliated companies or subsidiaries (*Position in lower-level firm*), and (3) positions in other firms/organizations (*Position in unrelated firm*).

Columns 1&2 report regression results for R&D expense and columns 3&4 report regression results for patent applications. The coefficients for *Position in upper-level firm* are positive and significant at 5% level or more in all four regressions. This suggests that top executives' engagement in upstream positions is detrimental to innovation input and output.

[3] According to the TEJ, the ultimate shareholder's cash-flow right is defined as the sum of multiples of ownership along each control chain, while its control right is defined as the sum of ownership at the end of each control chain. A detail example of calculating control right and cash-flow right is given in Appendix B.

From columns 2&4, the economic significance is such that firms with top executives engaging in upstream positions have innovation input 10.9% (=0.112/1.031) lower and innovation output 20.7% (=0.200/0.965) lower than those without. On the other hand, top executives' engagement in downstream positions enhances innovation, as indicated by positive and significant (1% level) coefficients of *Position in lower-level firm*. Firms with top executives engaging in downstream positions have innovation input 26.9% (=0.277/1.031) and innovation output 33.9% (=0.327/0.965) higher than those without. Top executives' concurrent positions in other firms or organization, however, has insignificant impact on innovation, as indicated by an insignificant coefficient of *Position in unrelated firm*.

Together with results in previous tables, that the negative coefficient of *Position in upper-level firm* and the positive coefficient of *Position in lower-level firm* is consistent with the entrenchment argument that when top executives serve more than one firm within group, they may concern their private benefits when allocating projects. In particular, they lean toward upper-level firms at the expense of lower-level firms in group. On the other hand, the result is inconsistent with the busyness argument predicting that those external positions divert top executives' effort and concentration and therefore result in less innovation activity.

[Insert Table 4]

We then examine if the impact of top executives' external position on innovation varies with listed firm's position in group and report the result of analysis in Table 5. Compared with Table 4, we include *Level in group* and its interaction with *Position in upper-level firm* as additional key variables for regressions in Table 5. In all regressions, the coefficient of *Level in group* is still negative and significant at 1% level after controlling for various top executives' external positions. Moreover, the coefficient of *Position in upper-level firm* is negative and significant at 1% level and the coefficient of *Position in lower-level firm* is positive and significant for all regressions. Both findings are consistent with those documented in previous tables. This suggests the two factors, firm's position in group and top executives' upstream positions, exert different effects on innovation. The coefficients of other variables for top executives' external positions are qualitatively the same as those in Table 4.

More importantly, the coefficient of interaction term for *Position in upper-level* and *Level in group* is positive and significant at 1% level for all regressions. This suggests that while top executives' engagement in upstream positions is detrimental to innovation in general, they may enhance innovation for listed firms at the bottom of group pyramid.

[Insert Table 5]

In sum, our above findings suggest that in China, a listed firm becomes less innovative when it is located at a lower level of pyramid but the result is unlikely due to the ultimate shareholder's incentive to tunnel resources from low-level listed firms in group. A firm's top executives' engagement in upstream positions also affects its innovation but the effect depends on the firm's location in group. In particular, those positions deter innovation when the firm is close to the ultimate parent while they enhance innovation when the firm is further away from the ultimate parent. Finally, a listed firm becomes more innovative when its CEO or board chair also work for a downstream firm, i.e. affiliated company or subsidiary.

3.3 Robustness checks

The above conclusion is subject to a number of empirical challenges. The first one is the endogeneity concern. For instance, some business groups may have specific needs and reasons to send managers from upper level firms to lower level firms but due to data non-availability, those factors cannot be captured by our regression model. Besides, it is possible that a firm's lower level of innovation arouses large shareholders to send top executives to the firm to enhance the innovation activity. If either case exists, our regressions could produce biased estimates.

To control for potential endogeneity problems in our regression, we perform treatment-effect regressions for R&D expense and patent applications. To implement the treatment-effect model, we need to find valid instrument(s) for top executives' decision to take upstream positions. In particular, the instrument must be significantly correlated with the endogenous variable, i.e. *Position in upper-level firm*, but uncorrelated with the error terms of regression models of R&D expense and patent applications. We use the wedge of control right and cash-flow right (*Control right*/*Cashflow Right*) because Table 3 shows that the variable is uncorrelated with R&D expense and patent applications. On the other hand, the Pearson correlation between *Position in upper-level firm* and *Control right*/*Cashflow Right* is 0.11 and significant at 1% level. Therefore, *Control right*/*Cashflow Right* is a valid instrument econometrically.

Theoretically, *Position in upper-level firm* should be positively related to *Control right*/*Cashflow Right* for the following reason. By construction, a large wedge between the control right and the cash-flow right suggests the ultimate parent control a listed firm through a control chain with relatively small actual ownership (the cash-flow right). If the ultimate parent does not have a majority ownership in any intermediate firm in the control chain, its control over the listed firm will be shaky because other shareholders of the intermediate firm may collectively work against the largest shareholder. To secure its control, the ultimate parent could send an agent to the listed firm to ensure the listed firm's CEO or board chair directly reports to it. On the other hand, a small wedge between the control right and the cash-flow right suggest that the ultimate shareholder maintains sufficient ownership in every intermediate firm in the control chain. Without competition for control from other shareholders, the ultimate shareholder has little need to send an agent from the top to monitor the listed firm.

Table 6 reports the treatment-effect regression results. Columns 1&2 report the treatment-effect regression for R&D expense. *Athrho* is the transformed correlation between error terms of the two regressions in a treatment effect model. From the result, the value of *Athrho* is positive, indicating that unknown factors that affect innovation are positively correlated with unknown factors that affect a top executive's decision to engage in an upstream position. Moreover, the significant (1% level) value of *Athrho* calls for a proper control for the endogeneity problem.

The first-stage regression for the existence of upstream positions held by key executives (*Position in upper-level firm*) is reported in column 1. The coefficient of *Control right*/*Cashflow Right* is positively and significant at 1% level, suggesting that our instrument is highly correlated with our key variable *Position in upper-level firm*. Column 2 shows that after controlling for potential endogeneity problem, top executives' engagement in upstream positions still has a negative impact on innovation, as indicated by the negative and significant (1% level) coefficient of *Position in upper-level firm*. However, for firms at very low levels of pyramid, those upstream positions enhance innovation, as indicated by the positive and significant coefficient of *Level in group * Position in upper-level firm*. All findings are consistent with the main finding in Table 4. Columns 3&4 report the treatment-effect regression for patent applications and the result is qualitatively the same as that in Columns 1&2. Therefore, our main finding in Table 5 is robust after controlling for the endogeneity problem.

[Insert Table 6]

We also use propensity score matching (PSM) to minimize the impact of covariates on top executives' engagement in upstream positions. The identification issue arise when our objective is to examine the impact of those upstream positions on innovation (the treatment effect) but other explanatory variables in model may predict the propensity of existence of such positions (the treatment itself). PSM aims to control for the bias by making the treatment and the control group comparable with respect to observed characteristics.

To perform PSM analysis, we first identify the treatment group as firms with CEO or board chair taking upstream positions and the control group as firms without CEO and board chair taking upstream positions. We then run a logit regression to model the probability of being a treatment firm, with the model specified as the one in column (1) of Table 6. Finally, we match each treatment firm with a control firm (with replacement) using the nearest neighbor propensity score matching technique. To further ensure the closeness between the treatment and the control firm, we impose two additional criteria in matching. First, we require an state-owned enterprise (SOE)/non-SOE treatment firm to be matched with an SOE/non-SOE control firm because several previous studies for SOEs find that corporate pyramids affect financial performance of SOE firms (Fan et al 2013; Opie et al 2019) but so far no corresponding study exist for non-SOEs. Second, we require the treatment firm and the control firm to have the same value of *Level in group* because top executives of a lower-level firm generally have a higher propensity of engaging in an upper-level firm in group.

After matching, we run paired *t*-test for difference in innovation between treatment and control firms. Panel A reports test results for R&D expense, the innovation input. Part (a) reports test results for the overall sample. The result shows that treatment firms has more innovation input than control firms, a result that is inconsistent with the finding in regression analysis. We then separate firms into two groups according to *Level in group*, firms at level 3 or above and firms at level 4 or below. We group firms in this way because from coefficients of *Level in group * Position in upper-level firm* and *Position in upper-level firm* in Table 5, engagement in upstream positions enhances innovation input for listed firms at 4th level or below of group pyramid. The result indicates that difference in innovation input between treatment and control firms is significant (1% level) only for firms in lower levels of group pyramid. Parts (b) and (c) report sub-sample t-tests for non-SOEs and SOEs respectively. The result is generally consistent with the full-sample t-tests except that it is stronger for SOE sample. Therefore, after controlling for a firm's level in group, top executives' engagement in upstream positions is beneficial for innovation input of listed firms at low levels of group pyramid.

Panel B reports test results for patent applications, the innovation output. Part (a) reports test results for the overall sample. The result shows insignificant difference in innovation output between treatment and control firms. However, when firms are sub-sampled by *Level in group*, top executives' engagement in upstream positions deters innovation output of firms at higher levels of group pyramid, and the difference between treatment and control firms is significant at 5% level. On the other hand, for firms at lower level of group pyramids, those upstream positions enhance innovation output and the result is significant at 1% level. The finding generally conforms our results from regression analysis. Parts (b) and (c) report sub-sample t-tests for non-SOEs and SOEs respectively. The result indicates the enhancement effect of upstream positions for low-level firms mainly come from the non-SOE groups, while the detrimental effect of upstream positions for upper-level firms mainly come from the SOE groups.

In sum, Table 7 confirms our previous finding that top executives' engagement in upstream positions deter innovation of firms at upper levels of pyramid but enhance innovation of firms at lower levels of pyramid. Moreover, those positions have different impacts on innovation of SOEs and non-SOEs, but nevertheless are important for innovation of all listed firms in China.

[Insert Table 7]

Finally, it is possible that the group culture and practice may affect top executives' decisions to work for an upper level firm. In other words, their choices may be driven by the group's decision rather than their own will. As a result, the observed effect of top executives taking upstream positions on innovation may be an influence of group culture or practice. To address this concern, we check the robustness of our main findings by focusing on business groups that have both firms with upstream positions and firms without those positions. Focusing on this sub-group allows us to reduce the impact of group culture and practice on the propensity of upstream positions because the same group allow its CEO to engage or not engage in upper level firms. This strategy also removes very small business groups that have only one firm listed.

Table 8 report results from unpaired t-tests on innovation between firms with top executives taking upstream positions and those without. Panel A reports the t-test result on R&D and Panel B report the t-test result for patent applications. Both panels suggest that after removing small business groups and purging the effect of corporate culture and practice, top executives' engagement in upstream positions still deter innovation of firms at upper level in group, while enhance innovation of firms at lower level.

[Insert Table 8]

4. Conclusion

The convention view of corporate pyramid suggests that large shareholders expropriate minority shareholders of listed firms via a control chain that maintain a significant control right with a low actual ownership. Recent studies, however, suggest that the pyramidal structure shields managers of listed SOEs from political interference and therefore enhances value of those listed firms (Fan et al 2013; Opie et al 2019). As opposed to those studies that focus on the SOEs, our study examines the impact of corporate pyramid on innovation of all listed firms in China. Moreover, we examine if a firm's innovation is affected if its top executives (CEO or board chair) take concurrent positions within group.

We find that corporate pyramid structure is detrimental to innovation of listed firms in low levels of pyramid. Further analysis shows that the detrimental effect is not attribute to the ultimate shareholder's incentive to tunnel. Moreover, a firm generally becomes less innovate if its top executives engage in an upper-level firm but become more innovate if engage in a lower-level firm in group. However, when the listed firm is far away from the vertex of the group, its top executives' engagement in upper-level firms enhances innovation. The finding is robustness to a number of tests addressing endogeneity, bias due to confounding variables, and group culture effect. Our study suggests that the information gap rather than the tunneling incentive is likely to be the reason behind the effect of corporate pyramidal structure on innovation of listed firms.

Our results have significant implications for investors and regulators to monitor concurrent engagements by listed firms' top executives. In particular, it highlights costs and benefits of top executives' multiple engagements within group. On one hand, those cross-firm engagements facilitate information exchange among firms in the same group. On the other hand, top executives may be biased in making decisions when they weigh relative importance of positions in different firms. Therefore, regulators should impose additional measures to minimize negative impacts while keeping benefits of those concurrent engagements.

Reference

Acs, Z.J., and Audretsch, D.B., 1988. "Innovation in large and small firms: an empirical analysis," American Economic Review 78, 678-690.

Agrawal, A., Cooper, T., Lian, Q., and Wang, Q., 2013. "Common advisers in mergers and acquisitions: Determinants and consequences," Journal of Law and Economics 56, 691–740.

Almeida, H.V., and Wolfenzon, D., 2006. "A theory of pyramidal ownership and family business group," Journal of Finance 61, 2637–2680.

Almeida, H.V., Park, S.Y., Subrahmanyam, M.G., and Wolfenzon, D., 2011. "The structure and formation of business groups: Evidence from Korean chaebols," Journal of Financial Economics 99, 447–475.

Asker, J., and Ljungqvist, A., 2010. "Competition and the structure of vertical relationships in capital markets," Journal of Political Economy 118, 599-647.

Barker III, V.L., and Mueller, G.C., 2002. "CEO characteristics and firm R&D spending," Management Science, 48, 782-801.

Buchuk, D., Larrain, B., Muñoz, F., and Urzúa I., F., 2014. "The internal capital markets of business groups: Evidence from intra-group loans," Journal of Financial Economics 112, 190-212.

Cai, Y., and Sevilir, M., 2012. "Board connections and M&A transactions," Journal of Financial Economics 103, 327-349.

Chang, X., Fu, K., Low, A., and Zhang, W., 2015. "Non-executive employee stock options and corporate innovation," Journal of Financial Economics, 115, 168-188.

Chang, X., McLean, R.D., Zhang, B., and Zhang, W., 2018. "Do patents portend productivity growth? Global evidence from private and public firms," working paper.

Chang, X., Shekhar, C., Tam, L.H.K., and Yao, J., 2016. "The information role of advisors in mergers and acquisitions: Evidence from acquirers hiring targets' ex-advisors," Journal of Banking and Finance 70, 247-264.

Claessens, S., Djankov, S., Fan, J.P.H., and Lang, L.H.P., 2002. "Disentangling the incentive and entrenchment effects of large shareholdings," Journal of Finance 57, 2741-2771.

Custodio, C., Ferreira, M.A., and Matos, P., 2019. "Do general managerial skills spur innovation?" Management Science, 65, 459-476.

Dutta, S., and Fan, Q., 2012. "Incentives for innovation and centralized versus delegated capital budgeting," Journal of Accounting and Economics 53, 592-611.

Faleye, O., Kovacs, T., and Venkateswaran, A., 2014. "Do better-connected CEOs innovate more?" Journal of Financial and Quantitative Analysis 49, 1201-1225.

Fan, J.P.H., Wong, T.J., and Zhang, T., 2013. "Institutions and organizational structure: The case of state-owned corporate pyramids," Journal of Economics, Law and Organization 29, 1217-1252.

Fich, E.M., and Shivdasani, A., 2006. “Are busy boards effective monitors?” Journal of Finance 61, 689-723.

Hauser, R., 2018. “Busy directors and firm performance: Evidence from mergers,” Journal of Financial Economics 128, 16-37.

He, J., and Tian, X., 2018. “Finance and corporate innovation: A survey,” Asia-Pacific Journal of Financial Studies 47, 165-212.

Hirshleifer, D., Low, A., and Teoh, S.H., 2012. Are overconfident CEOs better innovators? Journal of Finance 67, 1457-1498.

Islam, E., and Zein, J., 2019. “Inventor CEOs,” Journal of Financial Economics, forthcoming.

Jiang, F., and Kim, K.A., 2015. “Corporate governance in China: A modern perspective,” Journal of Corporate Finance 32, 190-216.

Kato, T., and Long, C., 2006. “CEO turnover, firm performance, and enterprise reform in China: Evidence from micro data,” Journal of Comparative Economics 34, 796-817.

Khanna, T., and Thomas, C., 2009. “Synchronicity and firm interlocks in an emerging market,” Journal of Financial Economics 92, 182–204.

Khanna, T., and Yafeh, Y., 2007. “Business groups in emerging markets: Paragons or parasites?” Journal of Economic Literature 65, 331-372.

Mao, C.X., and Zhang, C., 2018. “Managerial risk-taking incentive and firm innovation: Evidence from FAS 123R,” Journal of Financial and Quantitative Analysis 53, 867-898.

Masulis, R.W., Pham, P.K., and Zein, J., 2011. “Family business groups around the world: Financing advantages, control motivations, and organizational choices,” Review of Financial Studies 24, 3556-3600.

Meliciani, V., 2000. “The relationship between R&D, investment and patents: a panel data analysis,” Applied Economics 32, 1429-1437.

Opie, W., Tian, G.G., and Zhang, H.F., 2019. “Corporate pyramids, geographical distance, and investment efficiency of Chinese state-owned enterprises,” Journal of Banking and Finance 99, 95-120.

Renneboog, L., and Zhao, Y., 2014. “Director networks and takeovers,” Journal of Corporate Finance 28, 218-234.

Sunder, J., Sunder, S.V., and Zhang, J., 2017. “Pilot CEOs and corporate innovation,” Journal of Financial Economics 123, 209-274.

Yuan, R., and Wen, W., 2018. “Managerial foreign experience and corporate innovation,” Journal of Corporate Finance 48, 752-770.

Table 1 Summary Statistics

This table presents the summary statistics. All continuous variables are winsorized at 1st and 99th percentiles to alleviate the effects of outliers. The definitions of all variables are available in Appendix A.

Variables	Obs	Mean	SD	1%	50%	99%
Dependable variable						
R&D/Assets (R&D)	17404	1.031	1.572	0	0.004	7.699
Patent Applications/#employees (Pat)	17404	0.965	1.867	0	0.205	11.564
Key independent variables						
Level in group	17331	3.134	0.991	2	3	6
Control right / cashflow right	17370	1.337	0.813	1	1	6.450
Position in upper-level firm	17404	0.572	0.495	0	1	1
Position in lower-level firm	17404	0.332	0.471	0	0	1
Position in unrelated firm	17404	0.456	0.498	0	0	1
Other variables						
Ln(Assets)	17404	21.869	1.276	19.114	21.725	25.722
Ln(Firm age)	17404	2.668	0.383	1.386	2.708	3.332
Ln(PPE/#employees)	17404	12.507	1.146	9.504	12.459	15.844
Ln(Sales/#employees)	17404	13.658	0.990	11.491	13.546	16.762
ROA	17404	0.0349	0.062	-0.247	0.034	0.209
Sales growth	17404	0.212	0.619	-0.636	0.111	4.590
Leverage	17404	0.471	0.224	0.050	0.471	1.136
Cash/Assets	17404	0.181	0.134	0.008	0.144	0.650
Stock return	17404	0.420	0.867	-0.741	0.200	3.750
Tobin's Q	17404	2.720	2.121	0.887	2.040	13.70
Board size	17404	8.919	1.819	5	9	15
Duality	17404	0.209	0.407	0	0	1
SOE	17404	0.484	0.500	0	0	1
% of supervisors taking non-key positions in upper-level firm	17404	0.199	0.234	0	0.143	0.750
Hightech	17404	0.295	0.456	0	0	1

Table 2 Level in Group and Innovation

This table presents regression results for the effect of listed firm's position in group on the firm's innovation. The dependent variable is 100 times R&D scaled by total assets in column (1) and (2) and 100 times patent applications scaled by total employees in column (3) and (4). The key independent variable is *Level in group,* the level of the listed firm in business group. For example, it takes a value of three (3) if a firm is two layers from the ultimate parent. OLS model is estimated in column (1) and (3) and Tobit model is estimated in column (2) and (4). All continuous variables are winsorized at 1st and 99th percentiles to alleviate the effects of outliers. Heteroscedasticity robust standard errors, clustered by firm, are reported in parentheses. p<0.1, p<0.05 and p<0.01 levels of significance are represented as *, ** and *** respectively. The definitions of all variables are available in Appendix A.

	(1)	(2)	(3)	(4)
Variables	*R&D-OLS*	*R&D-Tobit*	*Pat-OLS*	*Pat-Tobit*
Level in group	-0.093***	-0.149***	-0.089***	-0.146***
	(0.018)	(0.031)	(0.024)	(0.036)
Ln(Assets)	-0.023	0.025	-0.065**	0.091**
	(0.019)	(0.036)	(0.028)	(0.042)
Ln(Firm age)	-0.550***	-1.103***	-0.271***	-0.521***
	(0.056)	(0.087)	(0.076)	(0.104)
Ln(PPE/#employees)	-0.146***	-0.290***	0.121***	0.097**
	(0.019)	(0.038)	(0.029)	(0.048)
Ln(Sales/#employees)	0.057***	0.089**	0.285***	0.385***
	(0.021)	(0.044)	(0.035)	(0.058)
ROA	1.853***	3.380***	0.745**	1.713***
	(0.285)	(0.554)	(0.342)	(0.565)
Sales growth	-0.042***	-0.110***	-0.079***	-0.187***
	(0.014)	(0.032)	(0.021)	(0.038)
Leverage	-0.648***	-1.215***	-0.520***	-1.044***
	(0.092)	(0.183)	(0.132)	(0.222)
Cash/Assets	0.373**	0.616**	0.746***	0.756***
	(0.154)	(0.243)	(0.205)	(0.288)
Stock return	-0.009	0.001	0.052*	0.118***
	(0.019)	(0.036)	(0.027)	(0.040)
Tobin's Q	0.035***	0.003	0.012	-0.034
	(0.011)	(0.019)	(0.016)	(0.025)
Board size	0.017	0.040**	-0.018	-0.012
	(0.010)	(0.019)	(0.015)	(0.023)
Duality	0.086*	0.111	0.171***	0.248***
	(0.045)	(0.068)	(0.062)	(0.081)
Constant	2.743***	1.762**	-2.865***	-7.773***
	(0.426)	(0.814)	(0.766)	(1.122)
Observations	17,331	17,331	17,331	17,331
R-squared	0.400		0.191	
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes

Table 3 Control Right-Cashflow Right Divergence and Innovation

This table presents regression results for the effect of divergence in control right and cash-flow right on corporate innovation. The dependent variable is 100 times R&D scaled by total assets in column (1) and (2) and 100 times patent applications scaled by total employees in column (3) and (4). The key independent variable is *Control right / Cashflow right,* the ultimate controller's total control right scaled by its total cash flow right. OLS model is estimated in column (1) and (3) and Tobit model is estimated in column (2) and (4). All continuous variables are winsorized at 1st and 99th percentiles to alleviate the effects of outliers. Heteroscedasticity robust standard errors, clustered by firm, are in parentheses. p<0.1, p<0.05 and p<0.01 levels of significance are represented as *, ** and *** respectively. The definitions of all variables are available in Appendix A.

	(1)	(2)	(3)	(4)
Variables	*R&D-OLS*	*R&D-Tobit*	*Pat-OLS*	*Pat-Tobit*
Control right/Cashflow right	-0.006	0.006	0.007	0.042
	(0.019)	(0.035)	(0.027)	(0.042)
Ln(Assets)	-0.026	0.015	-0.070**	0.083**
	(0.019)	(0.036)	(0.028)	(0.042)
Ln(Firm age)	-0.596***	-1.180***	-0.317***	-0.601***
	(0.055)	(0.086)	(0.075)	(0.102)
Ln(PPE/#employees)	-0.141***	-0.280***	0.123***	0.102**
	(0.019)	(0.038)	(0.029)	(0.048)
Ln(Sales/#employees)	0.054***	0.086*	0.285***	0.386***
	(0.021)	(0.044)	(0.035)	(0.058)
ROA	1.879***	3.434***	0.766**	1.724***
	(0.288)	(0.558)	(0.342)	(0.566)
Sales growth	-0.041***	-0.105***	-0.078***	-0.182***
	(0.014)	(0.033)	(0.021)	(0.038)
Leverage	-0.688***	-1.283***	-0.558***	-1.112***
	(0.092)	(0.184)	(0.132)	(0.222)
Cash/Assets	0.377**	0.635***	0.746***	0.765***
	(0.155)	(0.244)	(0.205)	(0.287)
Stock return	-0.003	0.013	0.057**	0.127***
	(0.019)	(0.036)	(0.027)	(0.040)
Tobin's Q	0.036***	0.003	0.011	-0.035
	(0.012)	(0.020)	(0.016)	(0.025)
Board size	0.016	0.037*	-0.019	-0.014
	(0.011)	(0.019)	(0.015)	(0.023)
Duality	0.111**	0.153**	0.195***	0.288***
	(0.045)	(0.068)	(0.062)	(0.081)
Constant	2.605***	1.605*	-2.979***	-7.982***
	(0.432)	(0.824)	(0.761)	(1.119)
Observations	17,370	17,370	17,370	17,370
R-squared	0.397		0.189	
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes

Table 4 Top Executives' Concurrent Positions and Innovation

This table presents regression results for the effect of top executives' concurrent positions on corporate innovation. The dependent variable is 100 times R&D scaled by total assets in column (1) and (2) and 100 times patent applications scaled by total employees in column (3) and (4). *Position in upper-level firm* is an indicator that equals one if firm's CEO or board chair works for at least one one upper-level company controlled by the ultimate shareholder. *Position in lower-level firm* is an indicator that equals one if firm's CEO or board chair works for an affiliated company or a subsidiary. *Position in unrelated firm* is an indicator that equals one if firm's CEO or board chair works for other than above companies or organizations. OLS model is estimated in column (1) and (3) and Tobit model is estimated in column (2) and (4). All continuous variables are winsorized at 1st and 99th percentiles to alleviate the effects of outliers. Heteroscedasticity robust standard errors clustered by firm are in parentheses. p<0.1, p<0.05 and p<0.01 levels of significance are represented as *, ** and *** respectively. The definitions of all variables are available in Appendix A.

	(1)	(2)	(3)	(4)
Variables	*R&D-OLS*	*R&D-Tobit*	*Pat-OLS*	*Pat-Tobit*
Position in upper-level firm	-0.079**	-0.112**	-0.157***	-0.200***
	(0.032)	(0.057)	(0.050)	(0.072)
Position in lower-level firm	0.142***	0.277***	0.160***	0.327***
	(0.036)	(0.059)	(0.051)	(0.070)
Position in unrelated firm	0.047	0.082	-0.046	-0.045
	(0.030)	(0.053)	(0.041)	(0.060)
Ln(Assets)	-0.022	0.023	-0.060**	0.096**
	(0.019)	(0.036)	(0.028)	(0.042)
Ln(Firm age)	-0.567***	-1.126***	-0.289***	-0.544***
	(0.055)	(0.086)	(0.075)	(0.102)
Ln(PPE/#employees)	-0.144***	-0.286***	0.120***	0.098**
	(0.019)	(0.038)	(0.029)	(0.048)
Ln(Sales/#employees)	0.055***	0.085*	0.287***	0.387***
	(0.021)	(0.044)	(0.035)	(0.058)
ROA	1.849***	3.358***	0.753**	1.659***
	(0.285)	(0.552)	(0.341)	(0.563)
Sales growth	-0.038***	-0.100***	-0.076***	-0.178***
	(0.014)	(0.033)	(0.021)	(0.038)
Leverage	-0.657***	-1.213***	-0.534***	-1.056***
	(0.091)	(0.182)	(0.133)	(0.223)
Cash/Assets	0.374**	0.643***	0.726***	0.742***
	(0.155)	(0.243)	(0.204)	(0.286)
Stock return	-0.008	0.002	0.051*	0.116***
	(0.019)	(0.036)	(0.027)	(0.040)
Tobin's Q	0.037***	0.007	0.013	-0.031
	(0.012)	(0.019)	(0.015)	(0.025)
Board size	0.016	0.037*	-0.019	-0.013
	(0.010)	(0.019)	(0.015)	(0.022)
Duality	0.096**	0.135**	0.159**	0.244***
	(0.045)	(0.068)	(0.062)	(0.081)
Constant	2.466***	1.335	-3.159***	-8.267***
	(0.430)	(0.820)	(0.758)	(1.121)
Observations	17,404	17,404	17,404	17,404
R-squared	0.401		0.192	
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes

Table 5 Group Level, Concurrent Positions and Innovation

This table presents regression results for the effect of listed firm's level in group and its top executives' concurrent positions on innovation. The dependent variable is 100 times R&D scaled by total assets in column (1) and (2) and 100 times patent applications scaled by total employees in column (3) and (4). The additional key independent variable is cross term of *Level in group* and *Position in upper-level firm*. OLS model is estimated in column (1) and (3) and Tobit model is estimated in column (2) and (4). All continuous variables are winsorized at 1st and 99th percentiles to alleviate the effects of outliers. Heteroscedasticity robust standard errors clustered by firm are in parentheses. p<0.1, p<0.05 and p<0.01 levels of significance are represented as *, ** and *** respectively. The definitions of all variables are available in Appendix A.

	(1)	(2)	(3)	(4)
Variables	*R&D-OLS*	*R&D-Tobit*	*Pat-OLS*	*Pat-Tobit*
Level in group	-0.161***	-0.292***	-0.149***	-0.268***
	(0.024)	(0.043)	(0.033)	(0.049)
*Level in group * Position in upper-level firm*	0.138***	0.285***	0.148***	0.275***
	(0.031)	(0.056)	(0.039)	(0.059)
Position in upper-level firm	-0.465***	-0.885***	-0.586***	-0.983***
	(0.108)	(0.185)	(0.141)	(0.201)
Position in lower-level firm	0.127***	0.253***	0.145***	0.300***
	(0.036)	(0.059)	(0.051)	(0.071)
Position in unrelated firm	0.049	0.085	-0.080	-0.142
	(0.030)	(0.053)	(0.076)	(0.124)
Ln(Assets)	-0.021	0.029	-0.057**	0.103**
	(0.019)	(0.036)	(0.027)	(0.042)
Ln(Firm age)	-0.520***	-1.047***	-0.248***	-0.473***
	(0.056)	(0.086)	(0.076)	(0.103)
Ln(PPE/#employees)	-0.145***	-0.288***	0.121***	0.098**
	(0.019)	(0.038)	(0.029)	(0.048)
Ln(Sales/#employees)	0.056***	0.088**	0.286***	0.386***
	(0.020)	(0.044)	(0.035)	(0.057)
ROA	1.798***	3.251***	0.712**	1.598***
	(0.282)	(0.549)	(0.340)	(0.562)
Sales growth	-0.040***	-0.106***	-0.077***	-0.184***
	(0.014)	(0.032)	(0.021)	(0.038)
Leverage	-0.609***	-1.143***	-0.484***	-0.972***
	(0.090)	(0.181)	(0.132)	(0.222)
Cash/Assets	0.363**	0.612**	0.728***	0.738**
	(0.153)	(0.241)	(0.204)	(0.287)
Stock return	-0.011	-0.005	0.049*	0.112***
	(0.019)	(0.036)	(0.027)	(0.040)
Tobin's Q	0.036***	0.006	0.014	-0.029
	(0.011)	(0.019)	(0.016)	(0.025)
Board size	0.016	0.039**	-0.018	-0.012
	(0.010)	(0.019)	(0.015)	(0.022)
Duality	0.084*	0.112*	0.149**	0.226***
	(0.045)	(0.067)	(0.063)	(0.081)
Constant	2.784***	1.866**	-2.900***	-7.817***
	(0.427)	(0.809)	(0.770)	(1.129)
Observations	17,331	17,331	17,331	17,331
R-squared	0.403		0.195	
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes

Table 6 Treatment-Effect Regression

This table presents treatment regression results innovation. Results from regressions for the treatment, i.e. *Position in upper-level firm*, are reported in columns (1) and (3), while results from regressions for the treatment effect, i.e. R&D and patent applications are reported in columns (2) and (4). In the treatment effect model, the dependent variable is 100 times R&D scaled by total assets in (2) and 100 times patent applications scaled by total employees in column (4). All continuous variables are winsorized at 1st and 99th percentiles to alleviate the effects of outliers. Heteroscedasticity robust standard errors, clustered by firm, are in parentheses. p<0.1, p<0.05 and p<0.01 levels of significance are represented as *, ** and *** respectively. The definitions of all variables are available in Appendix A.

	(1)	(2)	(3)	(4)
Variables	*Position in*	*R&D*	*Position in*	*Pat*
%Supervisor taking a non-key	0.131***		0.168***	
position in upper-level firm	(0.026)		(0.037)	
Level in group		-0.140***		-0.153***
		(0.024)		(0.034)
Level in group		0.138***		0.157***
** Position in upper-level firm*		(0.030)		(0.039)
Position in upper-level firm		-1.907***		-1.744***
		(0.170)		(0.585)
Position in lower-level firm		0.134***		0.161***
		(0.035)		(0.050)
Position in unrelated firm		0.043		-0.053
		(0.030)		(0.041)
Ln(Assets)	0.150***	0.057**	0.155***	-0.008
	(0.023)	(0.024)	(0.025)	(0.046)
Ln(Firm age)	0.139**	-0.452***	0.119**	-0.195**
	(0.060)	(0.066)	(0.060)	(0.083)
Ln(PPE/#employees)	-0.051**	-0.178***	-0.049**	0.046
	(0.022)	(0.022)	(0.023)	(0.031)
Ln(Sales/#employees)	0.051**	0.075***	0.052**	0.317***
	(0.025)	(0.025)	(0.026)	(0.039)
ROA	0.258	1.905***	0.257	0.785**
	(0.277)	(0.324)	(0.278)	(0.371)
Sales growth	0.025	-0.021	0.034*	-0.058**
	(0.017)	(0.016)	(0.017)	(0.024)
Leverage	0.235**	-0.540***	0.258**	-0.451***
	(0.106)	(0.105)	(0.110)	(0.153)
Cash/Assets	-0.155	0.300*	-0.142	0.883***
	(0.150)	(0.166)	(0.154)	(0.219)
Stock return	-0.036*	-0.026	-0.028	0.049*
	(0.019)	(0.022)	(0.019)	(0.028)
Tobin's Q	-0.003	0.034***	-0.002	0.020
	(0.011)	(0.012)	(0.011)	(0.015)
Board size	0.011	0.017	0.008	-0.016
	(0.012)	(0.012)	(0.012)	(0.016)
Duality	-0.522***	-0.187***	-0.531***	-0.047
	(0.049)	(0.061)	(0.048)	(0.137)
Constant	-3.809***	1.818***	-3.906***	-3.034***
	(0.558)	(0.526)	(0.604)	(0.968)
Athrho		0.752***		0.416*
		(0.079)		(0.228)
Observations	17,328	17,328	17,328	17,328
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes

Table 7 Propensity Score Matching

This table presents the t-test results of the means of difference in *R&D/Assets* (Panel A) and *Patent Applications / #employees* (Panel B) between the treat group and control group. The treat group is the sample of firms with CEO or board chair taking concurrent positions in upper-level companies and the control group is the sample of firms with CEO and board chair taking no concurrent positions in upper-level companies. The matching sample is selected using the nearest neighbor propensity score matching technique with replacement of control firm for each group level (from level 2 to level 6) and each state ownership status (SOE or non-SOE), employing a set of variables including *Control right/Cashflow right, Hightech, Ln(Assets), Firm age, PPE/#employees, Sales/#employees, ROA, Sales growth, Leverage, Cash/Assets, Stock return, Tobin's Q, Board size* and *Duality*. The numbers of matched sample pairs are in column (1). Mean values of innovation for treat group and control group are in column (2) and (3). The t-test for difference, (2) – (3), is reported in column (4). Panel A reports the results of *R&D/Assets* and panel B reports the results of *Patent Applications / #employees.* p<0.1, p<0.05 and p<0.01 levels of significance are represented as *, ** and *** respectively. The definitions of all variables are available in Appendix A.

Panel A- *R&D/Assets*	(1)	(2)	(3)	(4) = (2) – (3)
(a) Overall sample	*N pairs*	*Mean-treat*	*Mean-control*	*Diff*
Total	9683	0.860	0.797	0.063***
Group level 3 or above	6480	0.892	0.895	-0.003
Group level 4 or below	3203	0.795	0.598	0.197***
(b) Non-SOE sample				
Total	4042	1.169	1.121	0.048
Group level 3 or above	3103	1.306	1.276	0.030
Group level 4 or below	939	0.718	0.611	0.107*
(c) SOE sample				
Total	5641	0.639	0.564	0.075***
Group level 3 or above	3377	0.513	0.545	-0.032
Group level 4 or below	2264	0.827	0.593	0.234***

Panel B-Patent Applications / #employees	(1)	(2)	(3)	(4) = (2) – (3)
(a) Overall sample	*N pairs*	*Mean-treat*	*Mean-control*	*Diff*
Total	9683	0.809	0.823	-0.015
Group level 3 or above	6480	0.820	0.898	-0.078**
Group level 4 or below	3203	0.786	0.673	.0113***
(b) Non-SOE sample				
Total	4042	1.027	1.035	-0.007
Group level 3 or above	3103	1.114	1.187	-0.073
Group level 4 or below	939	0.740	0.532	0.208***
(c) SOE sample				
Total	5641	0.652	0.672	-0.020
Group level 3 or above	3377	0.550	0.632	-0.082**
Group level 4 or below	2264	0.805	0.731	0.074

Table 8 *T*-test of Sub-samples Within the Same Groups

This table presents the t-test results of the means of *R&D/Assets* (Panel A) and *Patent Applications / #employees* (Panel B) between firms with CEO or board chair engaging in upper-level firms (*upper1*) and firms without CEO and board chair engaging in upper-level firms (*upper0*) in same group. The numbers of the firms belonging to the two sub-samples are reported in column (1) and (2). Mean values of innovation the two sub-samples are reported in column (3) and (4). The unpaired t-test for the difference, (4) - (3), is reported in column (5). Panel A describes the results of *R&D/Assets* and panel B describes the results of *Patent Applications / #employees.* p<0.1, p<0.05 and p<0.01 levels of significance are represented as *, ** and *** respectively. The definitions of all variables are available in Appendix A.

Panel A	(1)	(2)	(3)	(4)	(5)
R&D/Assets	*N-upper0*	*N-upper1*	*Mean-upper0*	*Mean-upper1*	*Diff*
Total	1316	1623	0.717	0.817	0.100*
Group level 3 or above	751	667	0.861	0.725	-0.136*
Group level 4 or under	565	956	0.527	0.880	0.353***

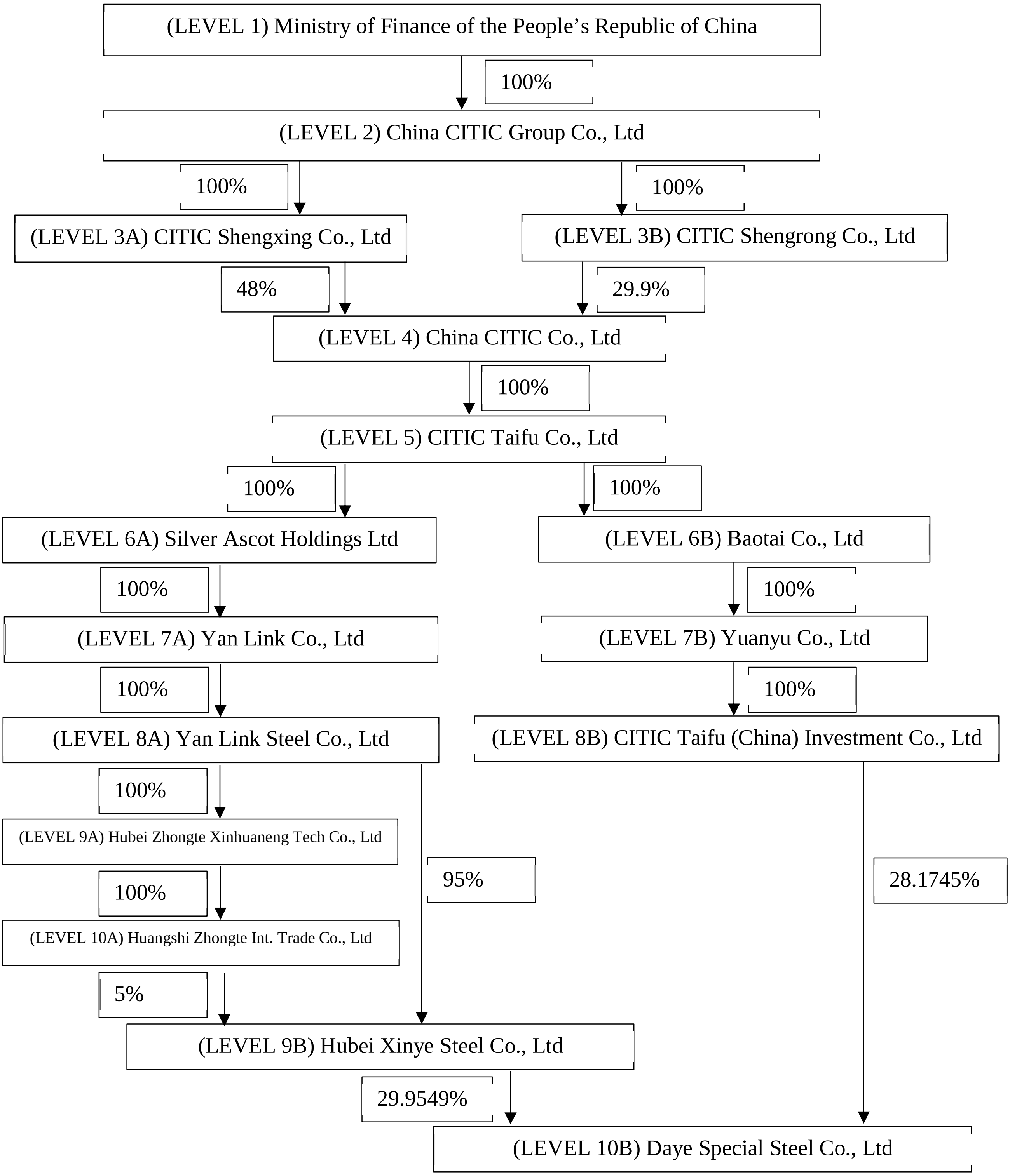
Panel B	(1)	(2)	(3)	(4)	(5)
Patent Applications / #employees	*N-upper0*	*N-upper1*	*Mean-upper0*	*Mean-upper1*	*Diff*
Total	1316	1623	0.904	0.897	-0.007
Group level 3 or above	751	667	1.083	0.887	-0.196*
Group level 4 or under	565	956	0.667	0.903	0.236**

Appendix A Variable Definitions

Variables	Definitions
Dependable variables	
R&D/Assets	100 times research and development expenditure scaled by total assets.
Patent Applications / #employees	100 times patent applications scaled by total employees.
Key independent variables	
Level in group	The level of the listed firm in business group. For example, if a firm is two level from the ultimate parent, its value will be three (3). Its value is capped at six (6) to reduce the impact of outliers.
Position in upper-level firm	An indicator that equals 1 if firm's CEO or board chair works for at least one upper-level company controlled by the ultimate shareholder.
Position in lower-level firm	An indicator that equals 1 if firm's CEO or board chair works for lower-level affiliated companies or subsidiaries.
Position in unrelated firm	An indicator that equals 1 if firm's CEO or board chair works for other companies other than categories above.
Control right / Cashflow right	The ultimate controller's total control right scaled by total cash flow right, the total control right is the sum of ownership at the end of each control chain and the total cash flow right is the sum of multiples of ownership along each control chain.
Other variables	
Ln(Assets)	The natural logarithm of total assets.
Firm age	The number of years elapsed since a firm established.
PPE/#employees	Net property, plant, and equipment (PPE) scaled by the number of employees.
Sales/#employees	Net sales scaled by the number of employees.
ROA	Net income scaled by total assets.
Sales growth	Change in net sales scaled by lagged net sales.
Leverage	Total liabilities scaled by total assets.
Cash/Assets	Cash holding scaled by total assets.
Stock return	Buy- and- hold stock returns computed over the fiscal year.
Tobin's Q	Tobin's Q value.
Board size	The number of total board directors.
Duality	An indicator that equals 1 if CEO and board chair is the same person.
SOE	An indicator that equals 1 if the firm is a state-owned company.
%Supervisor taking a non-key position in upper-level firm	Number of supervisors who have a concurrent but non-CEO and non-board chair position in upper-level firm scaled by total supervisors.
Hightech	An indicator that equals 1 if the firm is a high-tech firm.

Appendix B Example of Control Right and Cash-flow Right Calculation

Daye Special Steel Co., Ltd (Stock Code: 000708)



Control right: 29.9549%+28.1745%=58.1294%

Cash-flow right:

Line	Ownership Chain	Cash-flow Right
1	LEVEL 1 → (100%) LEVEL 2 → (100%) LEVEL 3A → (48%) LEVEL 4 → (100%) LEVEL 5 →(100%) LEVEL 6A → (100%) LEVEL 7A → (100%) LEVEL 8A → (100%) LEVEL 9A → (100%) LEVEL 10A → (5%) LEVEL 9B → (29.9549%) LEVEL 10B	0.7189%
2	LEVEL 1 → (100%) LEVEL 2 → (100%) LEVEL 3A → (48%) LEVEL 4 → (100%) LEVEL 5 → (100%) LEVEL 6A → (100%) LEVEL 7A → (100%) LEVEL 8A → (95%) LEVEL 9B → (29.9549%) LEVEL 10B	13.6594%
3	LEVEL 1 → (100%) LEVEL 2 → (100%) LEVEL 3B → (29.9%) LEVEL 4 → (100%) LEVEL 5 → (100%) LEVEL 6A → (100%) LEVEL 7A → (100%) LEVEL 8A → (100%) LEVEL 9A → (100%) LEVEL 10A → (5%) LEVEL 9B → (29.9549%) LEVEL 10B	0.4478%
4	LEVEL 1 → (100%) LEVEL 2 → (100%) LEVEL 3B → (29.9%) LEVEL 4 → (100%) LEVEL 5 → (100%) LEVEL 6A → (100%) LEVEL 7A → (100%) LEVEL 8A → (95%) LEVEL 9B → (29.9549%) LEVEL 10B	8.5087%
5	LEVEL 1 → (100%) LEVEL 2 → (100%) LEVEL 3A → (48%) LEVEL 4 → (100%) LEVEL 5→ (100%) LEVEL 6B → (100%) LEVEL 7B → (100%) LEVEL 8B → (28.1745%) LEVEL 10B	13.5238%
6	LEVEL 1 → (100%) LEVEL 2 → (100%) LEVEL 3B → (29.9%) LEVEL 4 → (100%) LEVEL 5→ (100%) LEVEL 6B → (100%) LEVEL 7B → (100%) LEVEL 8B → (28.1745%) LEVEL 10B	8.4242%
	Total	45.2828%