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Xiaping CAO
Shenzhen University

Tiecheng LENG
Sun Yat-sen University

Jeremy C. GOH
Singapore Management University, jeremygoh@smu.edu.sg

Paul MALATESTA
University of Washington

The innovation effect of dual-class shares: New evidence from US firms

Xiaping Cao[a], Tiecheng Leng[b*] , Jeremy Goh[c], Paul Malatesta[d]

a School of Economics, Shenzhen University, China
b Lingnan College, Sun Yat-sen University, China
c Singapore Management University, Singapore
d University of Washington, USA

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Abstract: The proliferation of dual-class structures in the US stock market presents a controversial trend since such shares are traditionally deemed to damage governance quality. We study the relationship between 362 firms with dual-class shares and their innovativeness using patent citations from Google Patents over the 1976 through 2006 period. We find dual-class shares have significant innovation effect in high-tech sectors, hard-to-innovate industries, firms with higher external takeover threat and firms heavily dependent on external equity financing. We also document a positive causality relationship between dual-class structures and the quality of innovation. The channel for this causal relationship is the protection mechanism by which managers can take a long-term view. From a policy perspective, regulators should promote a corporate governance system that protects corporate long-term interest for shareholders.

Keywords: Dual-class, Innovation, Patents, Citations, Corporate governance

1. Introduction

Dual-class shares which go against the precept of "one share one vote" have been debated extensively both in the industry and the academic circle. Some are calling for an outright ban (Govindarajan et al., 2018) while others see benefits in specific cases (Denis and Denis, 1994). Traditionally, "one share one vote" standard works well when shareholders emphasize quarterly or yearly corporate financial performance to evaluate insiders. However, for "new economy" companies, the variables reflecting corporate decision making may look different since many need to focus on long-term competitive advantage rather than short-term profitability.[1] This mismatch of spending and product cycle inevitably creates a conundrum since external shareholders with voting power intensively exert near-term earnings pressure on insiders.

When there is information asymmetry between insiders and external shareholders on long-term investments (DeAngelo and DeAngelo, 1985), the market typically penalizes insiders who are responsible for decision making. In fact, external shareholders generally do not understand what innovators are doing for the future as they mainly focus on near-term earnings growth, which will force managers to engage in short-term profit maximization. In situations whereby severe information asymmetry on long-term investment is present, dual-class share structures become an important economic device to solve the conflict between insiders and external shareholders. Dual-class shares render insiders/managers disproportionally more votes than shares they own (DeAngelo and DeAngelo, 1985; Moyer et al., 1992; Smart et al., 2008), hence insulating them from takeovers or short-term profitability pressure.

In recent years, economists have started studying firms' innovativeness.[2] Baranchuk et al. (2014) studying IPOs suggest that innovative firms are more likely to choose incentive systems emphasizing on long-term objectives. Similarly, DeAngelo and DeAngelo (1985) and

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Corresponding author. Xingang West Road, Haizhu, Guangzhou, 510275, China. E-mail addresses: xiaping@mit.edu (X. Cao), lengtch@mail.sysu.edu.cn (T. Leng).
[1] For example, technology firms need to make long-term investments because prolonged product development or research cycle requires substantial short-term R&D expenses (Hall et al., 1986).
[2] Examples include Mallick and Sousa (2017), Nemlioglu and Mallick (2017), Bournakis et al. (2018) and Bournakis and Mallick. (2018).

Chemmuneur and Jiao (2012) argue that firms adopting dual-class stock structures will focus on long-term projects. However, empirical efforts to relate dual-class structures with corporate innovation are scant. A few exceptions include Chemmanur and Tian (2018) and Baran et al. (2018), both focusing on dual-class structure as one special type of anti-takeover provisions (ATPs). Recognizing that innovation may be the most vital factor for building competitive advantages in companies especially technological ones (Porter, 1992), we employ several corporate innovation measures to explore whether the adoption of dual-class shares stifles or encourages innovation.

We consider several market disciplining forces that are mostly relevant for corporate competitiveness and innovation. Giroud and Mueller (2010) suggest that corporate governance may not be relevant in highly competitive industries since external governance is largely at work. For high-tech firms, innovation is pivotal and uses of dual-class structures allow insiders and management to focus on impactful innovations. Similarly, for firms operating in hard-to-innovate industries, innovation can be costly, high risky and vital. Thus, managers need greater job security in pursuing impactful innovation that will eventually maximize their long-term value. Conversely, the threat of takeover is one of the most important external mechanisms for aligning the interest of managers and shareholders (Jensen, 1986; Scharfstein, 1988; Hirshleifer and Thakor, 1998; Shleifer and Vishny, 1989). We therefore expect external takeover threat will affect the relation between dual-class structures and innovation. Similarly, firms with greater dependence on external equity financing are more likely to be disciplined by the market (Kaplan and Zingales, 1997). Tang (2019) shows hedge fund activism improve innovation efficiency, while Shen et al. (2019) finds corporate control by insiders matters for innovation in Chinese firms. If monitoring by external shareholders helps align incentives of insiders to achieve long-term interest, insiders may not necessarily resort to extreme control approach, that is, to adopt dual-class structures. This suggests that the relationship between dual-class structures and innovation will vary according to degree of equity dependence of firms.

To test these hypotheses, we follow the Kogan et al. (2017)'s methodology and construct patent data for 7239 single- and 362 dual-class share structure firms from Google Patents and CRSP over the 1976 through 2006 period.[3] We consider two measures of innovations: the number of patents and the average of citations in patents to gauge the impactful of patents since some patents are not utilized. These two measures are consistent with the common practice in the literature (Atanassov, 2013; Balsmeier et al., 2017; He, and Tian, 2013; Tian and Wang, 2014). We document novel evidence suggesting that firms that choose dual-class control structures can be more innovative in terms of patent quality. Specifically, we find that dual-class shares have no negative effect on patent counts but they are positively and significantly associated with a firm's average citations of patents. However, we find that not all firms with dual-class shares are innovative. The following types of firms are those that show a positive effect of dual-class structures on innovations: (1) high-tech firms, (2) firms operating in hard-to-innovate industries, (3) firms in states with high takeover threats, and (4) firms with high equity dependence measured with the Kaplan and Zingales (1997)'s KZ index.

Next, we investigate whether there is a causality relationship between dual-class share structure and firm's innovativeness. We use the maximum likelihood estimation (MLE) methodology to estimate the choice of dual-class share structure and variables that affect firm's innovation. We further employ a difference-in-difference model to exploit the natural experiment created by the Sarbanes-Oxley Act (SOX) enacted in 2002. We find the interaction term of SOX and dual-class share structures has significant and positive coefficient estimates for both patents and citations. This result suggests that dual-class structures render firms adopting such control mechanism greater innovative capacity when regulations tighten managerial discretions. It also sheds light on the market mechanism or channel by which dual-class structures result in higher quality innovation. One plausible explanation is that the dual-class shares enable managers to take a long-term view without worrying too much about short-term earnings pressure. This is not the case for single-class firms, especially after the enactment of SOX. Managers of single-class firms are faced with a combination of strict rules and stringent recordkeeping requirement. These managers will choose short-term profit maximization over long-term value creation.

We also rule out the possibility that the endogeneity problem on dual-class structures drives our findings. First, as the literature has established that the use of dual-class share structures is related to agency problems or poor governance, this self-adoption of dual-class structures works against our findings. If insiders abuse control and destroy value, corporations with dual-class structures should have fewer impactful innovations. We observe the opposite. Secondly, we address the endogeneity concern by using instrumental variable regressions (the instrument variables include industry percentage of dual-class firms in the past five years and state anti-takeover index). Both instrument variables (IV) are not firm specific, but they are related to industry structure or state legal reasons of why firms adopt dual-class shares. The first instrument captures a firm's choice of adopting dual-class structures due to peer pressures, and the second instrument similarly captures the external legal environment that protects insiders from takeover pressures. The IV regressions yield robust evidence that dual-class structures have a positive causality effect on innovation quality (citations per patent) but not necessarily quantity (patent counts). The findings suggest that dual-class structures improve creative innovation but not mediocre innovation, echoing the finding of Balsmeier et al. (2017). The difference is Balsmeier et al. (2017) investigate the channel of governance through independent directors, while ours is on managerial decision making or control power.

Our research contributes to the literature by providing new evidence on the proliferation of dual-class shares in U.S. market from increasingly important consideration of corporate innovation. Although the prior literature finds that such share structures result in the impairment of shareholder wealth, we show that dual-class structures should be considered as a new controlling mechanism with both positive and negative implications. The adoption of such shares enables insiders to focus on more important innovations and impactful patents. This paper thus provides evidence that dual-class shares enable managers to focus on long-term value creation of firms through innovations as competitive advantages.

The remainder of the paper is organized as follows. Section 2 introduces the background review. Section 3 describes our data and empirical methods. Section 4 presents the main results and reports the results of several robustness tests. Section 5 concludes with a summary of the findings and policy discussions.

2. Background review

Dual-class shares have become treated differently among stock exchanges. For example, Hong Kong and Singapore exchanges initially banned them completely. Although dual-class shares were popular during the 1960s in the UK, they are now near extinction. In continental Europe, dual-class shares are allowed but are not a prevalent phenomenon. The early popularity of dual-class shares was a response to corporate takeover threats especially hostile takeovers or shareholder activism (Jarrell and Poulsen, 1988). Due to the rise of corporate raiders in the US in 1980s, the NYSE lifted its ban on the listing of dual-class share structures in 1988, when the regulators were worried that great companies such as General Motors or General Electric would become the targets of corporate raiders.

[3] One advantage of this dataset is that it covers patents from 1976 to 2010. In contrast, patent data from NBER dataset only covers patent data up to 2006 but the coverage over the latter part of the database is incomplete. This is due to the grant lag since it on averages takes 2 years for a patent application to be granted by USPTA.

Today, the US market has witnessed dual-class structures in vogue again among the hottest high-tech initial public offerings, from Alibaba, Facebook to Zynga and Groupon. Not only have dual-class shares been welcomed in the IPOs of hot technology firms, but they are used by mature firms like Ford Motors and Berkshire Hathaway. For example, two founders of Google, Sergey Brin and Larry Page have more than 50% of the voting power but only hold less than 10% of shares outstanding (one share, ten voting rights). Similarly, Mark Zuckerberg enjoys more than 50% of voting rights of Facebook by holding shares with super voting rights. Starting in March 2004, dual-class shares attracted great attention and intense scrutiny when Alibaba announced that it would list its much-anticipated IPO in New York rather than in Hong Kong or Singapore. This has left the regulators in Hong Kong and markets to revisit their stance on a single-class share standard. Many corporate governance practitioners around the world expressed their concerns that dual-class shares may only benefit insiders or founders at the cost of external shareholders. With dual-class share structures, Alibaba's founding team can control the vote at the company (with more than 50% of the voting power) without having to own 50% of common shares. If dual-class shares are associated with inefficiency and lead to exacerbated agency problems, why does the market welcome a proliferation of such shares, especially in high-tech IPOs?[4]

In the face of dual-class share structures' increasing popularity, institutional investors start to scrutinize the downside of dual-class shares. CalPERS, for example, has decided to boycott all IPOs involving dual-class shares, arguing that dual-class shares create conflict between shareholders and management, destroy shareholder value and unfairly benefit the founders or executives.[5] Critics of dual-class shares argue that bad managers or insiders with great control power would insulate themselves from external monitoring. This is consistent with the notion that controlling shareholders often sacrifice public value to perpetuate their private benefits of control. Jarrell and Poulsen (1988), for example, show that dual-class shares exacerbate agency problems by protecting firms from hostile takeovers and giving managers job security and perquisites. Hanson and Song (1996) find that managers of dual-class firms are more likely to make value-decreasing acquisitions. Gompers et al. (2010), in constructing their original governance index, propose that the adoption of dual-class shares is indicative of poor corporate governance. For newly listed IPO firms, Smart and Zutter (2003) also demonstrate that IPOs with dual-class shares exhibit poorer performance and are traded at lower prices than IPO firms with single-class shares.

Supporters of dual-class shares, on the other hand, claim that such structures enable insiders to focus more on long-term projects and create long-term value for shareholders (DeAngelo and DeAngelo, 1985; Nguyen and Xu, 2010; Chemmuneur and Jiao, 2012). The debate on dual-class shares can be traced to the balance between competition and shareholder protection. Many academic studies focus on governance perspectives and find evidence that dual-class structures destroy value for shareholders (Smart et al., 2008; Masulis et al., 2009). The recent prevalence of dual-class shares warrants a systematic examination of dual-class shares. We thus revisit this important question by focusing on the effect of corporate innovation and competitive advantages of firms.

3. Data and variables

3.1. Patent data and firm characteristics

We obtain and construct our sample from the COMPUSTAT database for all US listed firms from 1970 to 2006. We exclude firms that are involved in major acquisitions, as well as firms that are domiciled outside U.S. We also require firms to have financial data available on COMPUSTAT for at least three consecutive years. Finally, we exclude firms in the financial industries and trusts. These filters result in a sample of 103,476 U.S. firm-year observations over the period 1970 to 2006.

In our analysis we control for an array of firm characteristics previously shown as significant determinants of innovation productivity. Hall and Ziedonis (2001), for example, argue that the number of patent applications and the number of patent citations are positively related to firm size. We therefore control for firm size, measured by the natural logarithm of total assets. We control also for research and development expenses divided by total firm assets. R&D expenses play an essential role in financing firm innovation (Atanassov, 2013). We additionally control for the following variables: firm age, measured by years elapsed since the firm was first listed (Firm Age); profitability, measured by operating income before depreciation divided by total assets (ROA); growth opportunities, measured by Tobin's Q (Tobin's Q); the ratio of cash flow (Cash Flow)to total firm assets; the debt-to-assets ratio (Leverage); the rate of investment in fixed assets, measured by capital expenditures (CAPX)divided by total firm assets; the ratio of property, plant and equipment (PPE)divided by firm assets; and product market competition, measured by the Herfindahl index of the 3-digit SIC industry code based on sales (Herfindahl Index). The construction of this measure follows Aghion et al. (2005) and Aghion et al. (2013).

Following the recent innovation literature, such as Seru (2014) for publicly traded firms and Lerner et al. (2011) for privately held firms, we measure a firm's innovation productivity using its patent activity, which indicates how effectively the firm transforms research expenditures or inputs into outputs. One measure of patent activity is the number of patent applications filed that are eventually granted subsequently. This captures the quantity of innovation output. We use the patent's application year instead of its grant year because, as Griliches et al. (1988) argue, a patent's application year better matches the time of innovation than the patent's grant year. Patents will appear in the NBER database only after being granted by the USPTO and it takes about two years on average for a successful patent application to be granted. We follow Kogan et al. (2017)'s method to construct patent data from Google Patents. The advantage of Google Patents is that it has a comprehensive coverage of patent data up to 2010 while NBER only reports patent data up to 2006. To avoid the bias of truncation due to granting gap for a patent, we choose the cutoff year to be 2006.

Patent counts do not distinguish ground-breaking inventions from incremental technological discoveries. Hence, to further assess a firm's innovation productivity, we examine the number of patent citations received (Hall et al., 2001, 2005), thereby capturing the quality of innovation output. Since citations are cumulative by nature, we choose 5 years window for each patent to gauge how it is utilized at each year. This method is suggested by Kogan et al. (2017) to control for filing period bias since early patents are more likely to receive more citations (Hall et al., 2001, 2005).[6]

3.2. Identifying dual-class firms

To develop our sample of dual-class companies, we begin with the sample in Gompers, Ishii, and Metrick's (2010) (hereafter, the GIM sample). The GIM sample is about the US public firms from 1994 to 2002. It is the most comprehensive of all readily available data sets on dual-class firms. We expand the GIM sample period from 1994 to 2002 to 1970–2006 b y drawing relevant dual-class data from the same primary sources that they used: Securities Data Company (SDC), S&P's COMPUSTAT, and the Center for Research in Security Prices (CRSP). The SDC's

[4] Wall Street Report on August 17, 2015 is titled "The big number, share of IPOs this year with dual-class stock structures."

[5] "Sorry CalPERS, dual-Class shares are a founder's best friend," *Forbes,* May 14, 2013.

[6] Hall et al. (2001, 2005) use an adjustment factor to address citation lag (both backward and forward lag).They correct for this additional source of truncation bias by dividing the observed citation counts by the fraction of predicted lifetime citations observed over the lag interval.

Global New Issues Database not only tracks corporate new issue activity from 1970 but flags those that have a separate class of common stock. In the CRSP database, we identify dual-class firms by their Committee on Uniform Security Identification Procedures (CUSIP) numbers. Following GIM (2010), those having the same 6-digit CUSIP number with different 2-digit extensions are considered to have dual-class share structures (Gompers et al., 2010). Firms that have a letter (A, B, C …) as part of their "share class" in the CRSP monthly database in a year are also defined as dual-class firms in that year. Finally, because the CRSP data reports one specific stock issue of a firm while COMPUSTAT contains all shares of all classes of a firm's stocks, we compare "shares outstanding" in CRSP with "common shares outstanding" in COMPUSTAT. When the difference is more than 1%, we identify that firm as dual-class. Merging all the above data together produces our final list of dual-class firms for 1970–2006.

We manually cross check our dual-class sample with GIM's sample and find in the overlapping years, the two samples are consistent. In total, firms with dual-class shares are not many compared to the whole sample of listed firms in the three major stock exchanges, NYSE, NASDAQ, and AMEX, accounting for approximately 10% of the whole sample.

3.3. Empirical method design

We use firm year patent counts as the dependent variables in the multivariate regressions. We control firm specific financial variables and characteristics including firm size, age, profitability, leverage, asset tangibility, growth opportunity, industry concentration index (Herfindahl index), and R&D expenses. The regression specification follows:

$$\mathrm{Log}\left(1+\mathrm{patent}_{\mathrm{i,t+1}}\right)=\alpha_{\mathrm{i}}+\beta\mathrm{Dual\ \ dummy}_{\mathrm{i,t+1}}+\sigma * controls_{i,t}+\varepsilon_{i,t+1}$$

The OLS (ordinary least squared) regressions control year and industry fixed effects and cluster standard error at firm level.

Since patent counts only measure a firm's quantity but not quality of innovation, we use an alternative measure of innovation following (Atanassov, 2013; Tian and Wang, 2014), citations per patent for a given firm year. This measure of citations control for the citation lag since older patents would receive more citations as time goes by.

$$\mathrm{Log}(1+\mathrm{Citations}\,/\,\mathrm{Patent}_{\mathrm{i,t+1}})=\alpha_{\mathrm{i}}+\beta\mathrm{Dual\ \ dummy}_{\mathrm{i,t+1}}+\sigma * controls_{i,t}+\varepsilon_{i,t+1}$$

Similarly, the OLS (ordinary least squared) regressions control year and industry fixed effects and cluster standard error at firm level. The dependent variable is the total citations received by all patents for a given firm year divided by patent counts for that firm. We take natural logarithm transformation to avoid skewness.

An empirical problem with the OLS regressions is the endogeneity concern. What beta in the regressions captures is the association between dual-class shares and innovation, while we are interested in the causation effect of dual-class shares on innovation. To address this question, we employ the instrument variable (IV) regressions like Heckman's two stage approach.

$$\mathrm{Dual\ \ Class}_{\mathrm{i,t+1}}=\mathrm{Probit}\ \ (\mu_{\mathrm{i}}+\mathrm{IV}_{\mathrm{i,t+1}}+\sigma CV_{i,t}+\varepsilon_{i,t+1})$$

$$\mathrm{Innovation}_{i,t+1}=\alpha_{\mathrm{i}}+\beta^{*}\mathrm{Predicted}\ \ (\mathrm{Dual\ \ Class}\ _{\mathrm{i,t+1}})+\theta Lambda_{\mathrm{i,t+1}}+\sigma CV_{i,t}+\varepsilon_{i,t_{i,t+1}}$$

The innovation variables include either the natural logarithm transformation of patent counts or citations deflated by patents for a given fiscal year. The Lambda in the second stage regression is the inverse Mills Ratio calculated by the first-stage Probit regression. The two IVs we use include industry average percentage of dual-class shares firms of prior 5 years and state anti-takeover index.

4. Empirical results

4.1. Summary statistics

Table 1A summarizes the innovation variables and firm characteristics for firms with single-class shares and those with dual-class shares. On average, single-class firms have an average of 13.57 patents per year. Firms with dual-class shares have an average of 6.59 patents per year. The other innovation measures such as average patent citations show similar patterns, that is, firms with dual-class shares have fewer citations per patents than firms with single-class shares. Other firm characteristics show that dual-class firms on average are larger, have higher ROA or Tobin's Q, more leveraged, and invest less in R&Ds than firms with single-class shares. The result suggests that we need control the difference in firm characteristics when comparing the effect of dual-class shares structures on innovation.

Industry characteristics matter for firms to choose whether to not adopting dual-class shares or single-class stocks. We therefore first divide the whole sample into high-tech and low-tech firms as well as hard-to innovate and easy-to-innovate industries, and compare the two types of firms. Table 1B reports the means of innovation variables such as patent counts and average citations per patent for a company for the subsamples according to industry characteristics. Furthermore, dual-class shares structures are shown to be related to takeover threats. We therefore use state anti-takeover laws to gauge the pressure for a firm to adopt dual-class shares structures. We do not use a firm's anti-takeover provisions because they are endogenous to either dual-class shares or innovation. Sapra et al. (2014) use the state-level antitakeover laws as the proxy for takeover and find a U-shaped relationship between innovation and takeover pressures. We divide the whole sample into two sub-samples according to a firm's registration state having low vs. high anti-takeover law provisions. In sum, firms with dual-class on average have fewer patent counts or citations per patent than firms with single-class shares. However, the pattern is not very consistent and the difference is not pronounced and many factors may contribute to such differences.

4.2. Baseline regression results

Table 2 reports the baseline multivariate regression results of the association between dual-class share structures and innovation activities. These pooled ordinary least squares regressions control for both year and industry fixed effects. The regressions calculate standard errors by clustering on firm levels. The main independent variable is a dual-class dummy, which equals one if the firm has dual-class shares in each year and zero otherwise. All regressions control for the logarithm of total assets, firm age, return on assets (ROA), Tobin's Q, cash flow, leverage, R&D expenses/assets, property, plant and equipment (PPE) and the Herfindahl index based on the three-digit SIC code (see Table 3).

As Table 2 shows, the estimated coefficients of the dual-class shares' dummy variable are insignificant in the regression on patent counts. The coefficients of the other independent variables are consistent with prior literature (Tian and Chemmanur, 2018). For example, innovation is positively related to firm size (sales), Tobin's Q, and tangibility while negatively related to firm age or leverage. On the other hand, dual-class share dummy is positively and significantly associated with citations per patent. Having adopted dual-class shares is associated with 0.17 increases in citations per patent, or 5% increase in average patent citations for a firm.

4.3. Impact of dual-class shares and industry characteristics on innovation

The recent proliferation of firms with dual-class share structures in the high-tech industries motivates the analysis presented in this section. We investigate whether dual-class share structures encourage or depress innovation in high-tech and low-tech firms and compare the effect

Table 1A

Summary Statistics. This table presents descriptive statistics for the sample of firms with single-class and dual-class shares during the period 1970–2006. Panel A reports summary statistics for the main four measures of firm innovation output. Panel B reports summary statistics for the control variables used in this study. Columns (1) to (4) and (5) to (8) report the number of firm-year observations (Obs), mean, median and standard deviation (S.D.) of the subsample that covers firms with single-class and dual-class shares, respectively.

	Single-Class Firms				Dual-Class Firms			
	Obs	Mean	Median	S.D.	Obs	Mean	Median	S.D.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Innovation Productivity Measurement								
Patent Counts	43259	13.57	0.00	108.67	3775	6.59	0.00	46.50
Citations per Patents	43259	3.85	0.00	13.68	3775	2.41	0.00	8.85
Panel B: Control Variables								
Total Assets in $ millions	43259	2616.35	216.86	14766.77	3421	4066.41	662.07	17953.56
Firm Age (years)	43259	14.30	11.00	9.88	3423	15.67	12.00	10.17
ROA (%)	43259	4.65	11.34	84.46	3421	10.25	12.28	26.02
Tobin's Q	43259	2.35	1.65	2.12	3421	1.92	1.47	1.55
Leverage (%)	43259	20.31	15.02	21.21	3421	28.26	24.76	24.89
CAPX/Assets	43259	6.59	4.20	7.85	3421	6.22	4.28	6.68
PPE/Assets (%)	43259	27.80	20.03	23.90	3423	29.62	23.34	22.59
R&D Expense/Assets (%)	43259	10.13	4.95	18.89	3421	5.12	1.58	13.00
Herfindahl Index	43259	20.75	15.99	16.32	3423	21.80	16.17	17.58

Table 1B

Summary Statistics. This table presents summary statistics of differences in innovation production between firms with single-class shares and those with dual-class shares. Panel A reports the mean in innovation between Low-Tech and High-Tech firms for those without and with dual-class share structures. Panel B reports the mean in innovation between firms that are in industries of Easy-to-Innovate and Hard-to-Innovate for firms without and with dual-class share structures. Panel C reports the mean in innovation between firms that are in states of Low anti-Takeover Index and High anti-Takeover Index for firms without and with dual-class share structures.

	Single-Class Firms				Dual-Class Firms			
	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean
	(1)	(2)	(5)	(6)	(5)	(6)	(7)	(8)
Panel A: Low vs. High-Tech Firms								
	Low-Tech		High-Tech		Low-Tech		High-Tech	
Patent counts	27248	7.92	16011	23.18	3183	3.90	592	23.81
Citations per patent	27248	2.12	16011	6.81	3183	1.69	592	6.31
Panel B: Easy vs. Hard-to-innovate Industries								
	Easy-to-innovate		Hard-to-innovate		Easy-to-innovate		Hard-to-innovate	
Patent counts	33928	6.46	9331	18.17	2806	4.34	969	9.77
Citations per patent	33928	2.15	9331	3.49	2806	3.11	969	3.18
	Low		High		Low		High	
Patent counts	18353	1.64	24906	15.98	1445	2.29	2330	8.26
Citations per patent	18353	2.90	24906	2.05	1445	3.25	2330	3.02

difference. We adopt Hall and Lerner (2009) taxonomy where the high-technology sector comprises pharmaceuticals, computing equipment, communications equipment and electronic components.

The relevant regressions on the subsamples of low-tech and high-tech firms are presented in Panels 1, 2, 3 and 4, respectively. It shows that for low-tech firms, dual-class shares structure has no effect on firm patent counts; in contrast, for hi-tech firms, dual-class shares have positive and significant effect on citations per patent for a given firm. We perform a F-test on the difference in estimated coefficients of dual-class shares dummy between low-tech and high-tech firms. The test shows that they are significantly different.

These results indicate that dual-class share structures affect innovation for high-tech firms but have no impact for low-tech firms. The effect on innovation only appears in the quality of patents (average citations per patent for a firm) but not the quantity of patents (patent counts). This evidence helps to explain why high-tech companies seem increasingly willing to adopt dual-class share structures. High-tech firms face great competition and they need to invest R&D for long-term projects. With dual-class shares, managers are able to make long-term decisions to benefit firms rather than only focus on short-term earnings. We show that dual-class share structures indeed improve high impact innovation but not necessarily quantity of innovation.

According to Hall et al. (2005), the Hard-to-Innovate industries are pharmaceuticals, medical instrumentation, chemicals, computers, communications, and the electrical industries. These industries face greater difficulty in their innovation activities due to the long time and high monetary cost to convert R&D expenses into patents. We thus test whether dual-class share structures have different effect on innovation for firms operating in easy-to-innovate vs. hard-to-innovate industries. We divide the whole sample into two subsamples and run regressions separately. The regression results are reported in Table 4. In all the regressions, we control firm and year fixed effects and calculate standard errors by clustering on firm levels.

The estimated coefficients of the dual-class dummy variables are only significant in the subsample of firms in hard-to-innovate industries when dependent variables are average firm citations per patent. The positive sign of coefficients suggests that adoption of dual-class shares has improves impactful patents but not necessarily quantity of patents.

4.4. *Impact of dual-class shares and external takeover threats on innovation*

Prior research indicates that insiders or executives adopt dual-class share structures to secure their own jobs and benefits when facing external takeover threats (Bebchuk and Cohen, 2003). For this reason, we examine how the effects of dual-class shares on innovation vary for firms

Table 2
Innovation and Share Class Structure. This table reports the estimation results of panel regressions examining the effects of dual-class shares on innovation productivity for the period from 1970 through 2006. We regress firm innovation output in year $t+1$ on a Dual-Class dummy variable that equals one if a firm has dual-class shares in year t and zero otherwise. The regressions control both firm and year fixed effects and cluster on firm level. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively using t-statistics for two-tailed tests. The t-values are reported in parentheses.

	$Ln(1+Pat)_{t+1}$	$Ln\left(1+\frac{Cit}{Pat}\right)_{t+1}$
	(1)	(2)
Dual class dummy	−0.0050	0.1262***
	[-0.18]	[3.02]
Q	0.0082***	0.0225***
	[3.75]	[6.50]
Ln(Firm age)	−0.1022***	−0.5959***
	[-5.66]	[-25.52]
Ln(Sales)	0.0539***	−0.0342***
	[6.36]	[-3.14]
ROA	−0.0362	0.1639***
	[-1.36]	[3.93]
Tangibility	0.1294***	0.5405***
	[3.02]	[8.33]
Leverage	−0.0563*	−0.0942**
	[-1.89]	[-2.46]
HHI	−0.2285	0.2721
	[-1.26]	[1.05]
R&D expenses/Assets	−0.0368	11.691**
	[-1.09]	[2.44]
Constant	0.6348***	2.0053***
	[13.02]	[28.55]
N	43931	43931
adj. R-sq	0.15	0.16
Firm FE	Yes	Yes
Year FE	Yes	Yes

with different exposures to takeover risk. We rely on takeover measures that are unrelated to firms' own characteristics, and therefore we do not use firm's own anti-takeover provisions. One useful proxy for external takeover risk is Bebchuk and Cohen (2003)'s state-level index of anti-takeover laws. This index takes integer values from zero to five, with higher values corresponding to more restrictive takeover laws and, hence, lower implied external takeover risk. In the regression analysis we divide the whole sample into two subsamples according to whether a firm is in states with high takeover threats or in states with low takeover threats. We measure high takeover threat is a state adopts few restrictive takeover law measures than the median value of anti-takeover law index.

We report the regression results in Table 5. The regressions control both year and industry fixed effects and calculate standard error of coefficient estimates by clustering at firm level. As shown in the table, dual-class shares structure calculated from the instrumental regression is not significantly associated with patent counts. However, the dual-class shares dummy has a positive and significant coefficient estimates on a firm's average citations per patent. The effect here is stronger for firms located in states facing low external takeover threats, those states with higher anti-takeover law index.

4.5. Impact of equity dependence and dual-class structures on innovation

Although dual-class structures provide managers or insiders great voting power and exacerbate agency problems, equity dependent firms relying on external equity financing for investment and expenses will improve governance (Jensen, 1986). We carry out a cross sectional identification strategy to test whether the effect of dual-class shares on corporate innovation varies according to equity dependence. For each firm, we calculate its KZ index (Kaplan and Zingales, 1997) to gauge equity dependence. We sort the whole sample into four quintiles according to each firm's KZ index each year industry, and run baseline

Table 3
Dual-Class Shares, High-Tech Industries, and Innovation. This table reports the estimation results of subsample regressions designed to measure how the effects of dual-class shares on innovation between High-tech industries and Low-tech firms. Following Hall and Lerner (2009), we define the high-technology industries as drugs, office and computing equipment, communications equipment and electronic components. We regress firm innovation output in year $t+1$ on a Dual-Class dummy variable that equals one if a firm has dual-class shares in year t and zero otherwise. The regressions control both firm and year fixed effects and cluster on firm level. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively using t-statistics for two-tailed tests. The t-values are reported in parentheses.

	$Ln(1+Pat)_{t+1}$		$Ln\left(1+\frac{Cit}{Pat}\right)_{t+1}$	
	Low-tech	High-tech	Low-tech	High-tech
	(1)	(2)	(3)	(4)
Dual class dummy	−0.0058	0.0035	0.0761**	0.3571***
	[-0.22]	[0.03]	[2.04]	[2.89]
Q	−0.0005	0.0134***	0.1537	0.0211***
	[-0.14]	[4.83]	[0.15]	[4.78]
Ln(Firm age)	−0.0621***	−0.1516***	−0.3634***	−0.9368***
	[-3.13]	[-4.65]	[-14.82]	[-22.01]
Ln(Sales)	0.0107	0.1190***	−0.0254**	−0.0691***
	[1.48]	[6.69]	[-2.37]	[-3.28]
ROA	0.0378	−0.1167***	0.2688***	0.1671***
	[1.09]	[-3.01]	[5.41]	[2.71]
Tangibility	0.1057**	0.1724	0.4243***	0.7810***
	[2.53]	[1.51]	[6.84]	[4.70]
Leverage	0.0313	−0.1809***	−0.0242	−0.1605**
	[0.95]	[-3.37]	[-0.56]	[-2.40]
HHI	−0.1902	−0.1554	−0.1590	0.1214
	[-1.19]	[-0.36]	[-0.70]	[0.19]
R&D Expense/ Assets	0.0527	−0.0587	0.1971	0.0839*
	[0.49]	[-1.35]	[0.96]	[1.66]
Constant	0.5475***	0.8655***	1.3109***	3.2621***
	[11.72]	[8.44]	[19.07]	[22.63]
N	28500	15431	28500	15431
adj. R-sq	0.13	0.12	0.15	0.18
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

regressions. The subsample test results are reported in Table 6. Panel A reports the regression results with patent counts as dependent variable and Panel B with citations per patent as dependent variable.

First, we find that dual-class shares have differing effect on patents. For example, in the quintile of firms with highest dependence on external equity financing reported in Column (4), dual-class shares do not have negative effect on corporate innovation. On the contrary, the effect is positive and significant. While in other three quintiles with lower equity dependence, dual-class shares have insignificant but negative effect on corporate patent counts. This test clearly suggests that dual-class shares do not smother corporate innovation, instead the structures improve patents for firms where external monitoring is important.

The results reported in Panel B show that dual-class shares have positive effect on impactful patents as measured as average citations per patent for each firm. Furthermore, when a firm's equity dependence increases, dual-class shares' effect on impactful innovation becomes larger in magnitude.

Overall, the results presented in Table 6 suggest that documented dual-class structures' innovation effect is not driven by endogeneity problems. If there is any endogeneity problem affecting the relationship between dual-class shares and innovation including agency concerns, the endogeneity problem only weakens our findings. The robust and positive effect of dual-class shares on corporate innovation reported in the different quintiles rule out the possibility that our result is driven by endogeneity issues.

Table 4
Dual-Class Shares, Hard-to-Innovate Industries, and Innovation. This table reports the estimation results of regressions designed to measure how the effects of dual-class shares on innovation productivity vary between Hard-to-Innovate industries (HTI) and other industries (non-HTI). As in Hall et al. (2005) and Tian and Wang (2014) we define the Hard-to-Innovate industries as the pharmaceutical, medical instrumentation, chemicals, computers, communications, and electrical industries. We regress firm innovation output in year $t + 1$ on a Dual-Class dummy variable that equals one if a firm has dual-class shares in year t and zero otherwise. The regressions control both firm and year fixed effects and cluster on firm level. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively using t-statistics for two-tailed tests. Thet-values are reported in parentheses.

	$Ln(1+Pat)_{t+1}$		$Ln\left(1+\frac{Cit}{Pat}\right)_{t+1}$	
	Non-HTI	HTI	Non-HTI	HTI
	(1)	(2)	(3)	(4)
Dual class dummy	0.0019	−0.0362	0.0870**	0.2940***
	[0.06]	[-0.60]	[1.97]	[2.90]
Q	0.0057**	0.0134***	0.0172***	0.0290***
	[2.26]	[3.30]	[3.85]	[5.33]
Ln(Firm age)	−0.1022***	−0.0887**	−0.5240***	−0.7608***
	[-5.25]	[-2.12]	[-19.92]	[-15.87]
Ln(Sales)	0.0374***	0.0918***	−0.0193*	−0.0708***
	[4.48]	[4.42]	[-1.65]	[-3.12]
ROA	−0.0146	−0.0888*	0.1288**	0.2481***
	[-0.48]	[-1.68]	[2.45]	[3.55]
Tangibility	0.1407***	0.1071	0.4376***	0.8087***
	[3.57]	[0.79]	[6.40]	[5.06]
Leverage	0.0299	−0.2347***	−0.0352	−0.1800**
	[0.94]	[-3.83]	[-0.78]	[-2.54]
HHI	−0.0205	−0.6264	−0.7031***	2.5709***
	[-0.12]	[-1.20]	[-2.67]	[3.71]
R&D Expense/	−0.0612	−0.0365	0.2044	0.0975**
Assets	[-0.91]	[-0.72]	[1.50]	[2.05]
Constant	0.5330***	1.0100***	1.8468***	2.4575***
	[10.84]	[7.64]	[23.72]	[15.79]
N	34268	9663	34268	9663
adj. R-sq	0.12	0.14	0.13	0.16
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 5
Dual-Class Shares, Takeover Threats, and Innovation. This table reports the estimation results of regressions designed to measure the effect of dual-class shares on innovation productivity for firms with different exposures to external takeover threats. We use the state-level index (from 0 to 5) of anti-takeover laws compiled by Bebchuk and Cohen (2003) as a proxy for external takeover pressure. The whole sample is divided into two: low ATR (state anti-takeover index below mean value) and high ATR (state anti-takeover index equal to or above mean value). We regress firm innovation output in year $t + 1$ on a Dual-Class dummy variable that equals one if a firm has dual-class shares in year t and zero otherwise. The regressions control both firm and year fixed effects and cluster on firm level. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively using t-statistics for two-tailed tests. The t-values are reported in parentheses.

	$Ln(1+Pat)_{t+1}$		$Ln\left(1+\frac{Cit}{Pat}\right)_{t+1}$	
	Low ATR	High ATR	Low ATR	High ATR
	(1)	(2)	(3)	(4)
Dual class dummy	−0.0244	0.0028	0.0452	0.1727***
	[-0.90]	[0.06]	[0.78]	[2.82]
Q	0.0072***	0.0101***	0.0092**	0.0285***
	[2.77]	[2.79]	[2.05]	[5.40]
Ln(Firm age)	−0.0814***	−0.1091***	−0.4504***	−0.7377***
	[-4.10]	[-3.11]	[-15.04]	[-18.30]
Ln(Sales)	0.0317***	0.0566***	−0.0084	−0.0369**
	[3.21]	[4.45]	[-0.56]	[-2.38]
ROA	−0.0026	−0.0759*	0.0258	0.2653***
	[-0.09]	[-1.79]	[0.55]	[3.76]
Tangibility	0.0670	0.1526**	0.1042	0.7654***
	[1.48]	[2.33]	[1.20]	[8.51]
Leverage	−0.0797***	−0.0416	−0.0420	−0.0861
	[-2.85]	[-0.85]	[-0.87]	[-1.45]
HHI	−0.3799*	−0.4310	0.0607	0.1980
	[-1.81]	[-1.52]	[0.18]	[0.53]
R&D Expense/	−0.0445	0.1291	−0.0757	0.8576***
Assets	[-1.37]	[1.27]	[-1.45]	[5.55]
Constant	0.5017***	0.8230***	1.4725***	2.5240***
	[9.35]	[9.59]	[17.01]	[21.38]
N	18484	25447	18484	25447
adj. R-sq	0.11	0.10	0.09	0.14
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

4.6. *Causality tests*

The cross-sectional identification tests suggest that dual-class shares have positive causality effect on corporate innovation. In this subsection, we will explore causality relationship between dual-class share structures and firms' innovation. We adopt the maximum likelihood estimation (MLE) methodology to conduct the causality tests, which entails estimating the selection and main equations simultaneously. The selection equation estimates the probability of a firm choosing a dual class structure by regressing the dual class dummy on other control variables in our main tests. By estimating the selection and main equations jointly, we test the null hypothesis that the two error terms in the two are independent using a likelihood-ratio test. The null can be rejected if the unobservable firm characteristics affecting the firms' choice of a dual class share structure also determine their innovation activity. Panel A of Table 7 reports the results of the MLE two-equation treatment model. For brevity, we suppress coefficient estimates of the control variables for all three estimation methods. However, the results are mostly consistent with those reported in the main regressions in Table 2. The likelihood ratio test indicates that we can reject the null hypothesis that the two errors terms are uncorrelated at the 1% level. This indicates that unobservable firm characteristics affecting the firm's choice of a dual class structure also determine its innovation activity.

Further, we use the propensity score matching (PSM) method to further control for self-selection bias. For each dual-class firm-year observation, we match it to a single-class firm-year observation based on the predicted propensity to adopt dual-class share structure estimated from a probit regression. We employ one-to-one nearest neighbor matching with replacement and the set of matching variables include Tobin's Q, firm age, and industry and year fixed effects. This approach mitigates the self-selection bias by estimating the differences in innovation activity between dual-class and comparable single-class firms. Panel B of Table 7 reports the estimation results from the propensity score matching model, which are consistent with those reported in our main regression model.

Finally, we employ a difference-in-difference model to exploit the natural experiment created by the Sarbanes-Oxley Act (SOX) enacted in 2002. Cao et al. (2016) finds that the adoption of the Sarbanes-Oxley Act of 2002 impedes corporate innovation. SOX dummy equals to one if the year is after 2002. Panel C of Table 7 reports the estimation results from this difference-in-difference model based on the Sarbanes-Oxley Act (SOX).

After we include SOX dummy in the regressions, dual class structures have no significant effect on either patents or citations. On the other hand, SOX has significant and negative effect on corporate innovations, consistent with Shadab (2008) and Cao et al. (2016). However, the interaction term of SOX and dual-class share structures has significant and positive coefficient estimates for both patents and citations. This result suggests that dual-class structures render firms adopting such control mechanism greater innovative capacity when regulations tighten managerial discretions. Dual-class structures' innovation effect is salient after the passage of SOX.

Table 6

Dual-Class Shares, Equity Dependence, and Innovation. This table reports the estimation results of panel regressions examining the effects of dual-class shares on innovation productivity for the period from 1970 through 2006. We divide the whole sample into four quintiles according to each firm's equity dependence (from lowest to highest equity dependence) measured by KZ index (Kaplan and Zingales, 1997) and regress firm innovation output in year $t+1$ on a Dual-Class dummy variable that equals one if a firm has dual-class shares in year t and zero otherwise in each quintile. The regressions control both firm and year fixed effects and cluster on firm level. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively using t-statistics for two-tailed tests. The t-values are reported in parentheses.

Panel A

	$Ln(1+Pat)_{t+1}$			
	Lowest quintile KZ index	Second quintile KZ index	Third quintile KZ index	Highest quintile KZ index
Dual class dummy	−0.0571	−0.0336	−0.010	0.1523**
	[-0.99]	[-0.65]	[-0.18]	[2.34]
Q	−0.0006	0.0104**	0.01835***	0.01438***
	[-0.99]	[2.28]	[3.31]	[2.67]
Ln(Firm age)	−0.1147***	−0.0876**	−0.1252***	−0.0926*
	[-4.70]	[-2.16]	[-3.19]	[-1.79]
Ln(Sales)	0.0261**	0.0736***	0.0830***	0.6369***
	[2.13]	[3.48]	[4.61]	[3.16]
ROA	0.0499	−0.0710	−0.2301***	−0.0481
	[1.42]	[-1.05]	[-3.35]	[0.69]
Tangibility	0.1214*	0.1761**	0.1538	0.0722
	[1.94]	[2.04]	[1.54]	[0.63]
Leverage	−0.0386	−0.1133**	−0.0466	0.0041
	[-0.88]	[-2.09]	[-0.81]	[0.04]
HHI	−0.0286	−0.0782	−0.2692	−0.0223
	[-0.28]	[-0.48]	[1.64]	[0.12]
R&D expenses/Assets	−0.0020	−0.1398	−0.0985	0.0456
	[-0.05]	[-1.37]	[-1.30]	[0.43]
Constant	0.7415***	0.5411***	0.5833***	0.4960***
	[11.77]	[5.04]	[5.42]	[4.41]
N	10991	10980	10980	10980
adj. R-sq	0.10	0.12	0.13	0.14
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Panel B

	$Ln\left(1+\frac{Cit}{Pat}\right)_{t+1}$			
	Lowest quintile KZ index	Second quintile KZ index	Third quintile KZ index	Highest quintile KZ index
Dual class dummy	0.0078	0.1336	0.2285**	0.2346***
	[0.12]	[1.58]	[2.21]	[2.85]
Q	−0.0013	0.0369***	0.0384***	0.0294***
	[-0.27]	[5.34]	[4.38]	[3.58]
Ln(Firm age)	−0.5649***	−0.6509***	−0.5583***	−0.5548***
	[-15.72]	[-13.20]	[10.55]	[-9.61]
Ln(Sales)	0.0586***	−0.0401*	0.0002	−0.0329
	[3.39]	[-1.74]	[0.01]	[-1.31]
ROA	0.1061	0.3981***	0.1006	0.3171***
	[1.54]	[4.29]	[1.03]	[2.97]
Tangibility	0.5609***	0.4611***	0.6547***	0.2582*
	[5.65]	[3.21]	[4.81]	[1.67]
Leverage	−0.1550**	−0.0352	−0.1245	−0.0527
	[−2.41]	[-0.49]	[-1.35]	[-0.57]
HHI	−0.0879	−0.0055	−0.5027**	−0.2362
	[-0.59]	[-0.03]	[-2.04]	[-1.22]
R&D expenses/Assets	0.0989	0.1396	0.4335	0.2749*
	[1.64]	[1.19]	[0.38]	[1.74]
Constant	2.1209***	2.2035***	1.8086***	1.9568***
	[20.85]	[15.52]	[11.72]	[12.71]
N	10991	10980	10980	10980
adj. R-sq	0.10	0.11	0.12	0.12
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

4.7. Further robustness checks and endogeneity tests

In this subsection, we provide further tests to control for the endogeneity of the firms' decision to have dual-class structure. Endogeneity arises when firm characteristics affecting the firm's choice of having a dual-class structure also determine its innovation activity. We rely on several alternative econometric methods to mitigate the endogenous selection of having a dual-class structure.

First, we use an instrumental variable (IV) approach to mitigate the effect of endogeneity of choosing a dual class structure. The IVs we choose include the industry average of firms adopting dual-class share structures of prior 5 years and the state level anti-takeover index. Both measures are exogenous to a firm's innovation measures but are correlated with the adoption of dual-class shares at industry level or state level. The Heckman's two stage regression results are reported in Table 7. In the first stage, we run a probit regression of adoption of dual-class shares on the two IVs, calculate the inverse Mills ratio or Lambda, and include Lambda as independent variable in the second stage OLS

Table 7
Causality Test of Dual-Class Structure on Innovation. This table reports regression results from three different estimation procedures: MLE (Panel A), propensity score matching (Panel B) and difference in difference (DID) based on SOX (Panel C). We regress firm innovation output in year $t+1$ on a Dual-Class dummy variable that equals one if a firm has dual-class shares in year t and zero otherwise. All regressions include firm and year fixed effects and control for firm characteristics as in the baseline regression model. In Panel C, we include an interaction term between dual class dummy and SOX dummy to estimate the DID model, where SOX dummy takes a value of one if the year is after 2002. For brevity, we suppress coefficient estimates of control variables. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively using *t*-statistics for two-tailed tests. The t-values are reported in parentheses.

Panel A: Maximum Likelihood Estimation (MLE)		
	$Ln(1+Pat)_{t+1}$	$Ln\left(1+\frac{Cit}{Pat}\right)_{t+1}$
	(1)	(2)
Dual class dummy	−0.0318	0.0730***
	[-1.47]	[2.76]
N	43931	43931
Controls	Yes	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes
Panel B: Propensity Score Matching		
	$Ln(1+Pat)_{t+1}$	$Ln\left(1+\frac{Cit}{Pat}\right)_{t+1}$
Dual class dummy	−0.0795	0.1716**
	[-1.39]	[2.18]
N	7110	7110
adj. R-sq	0.003	0.080
Controls	Yes	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes
Panel C: Difference-in-Difference based on Sarbanes-Oxley Act (SOX)		
	$Ln(1+Pat)_{t+1}$	$Ln\left(1+\frac{Cit}{Pat}\right)_{t+1}$
Dual class dummy	−0.0476	−0.0062
	[-1.62]	[-0.15]
SOX * Dual class dummy	0.0461*	0.1615***
	[1.69]	[4.30]
SOX	−0.1260***	−0.3800***
	[-11.47]	[-25.91]
N	43931	43931
adj. R-sq	0.023	0.120
Controls	Yes	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes

regressions to control the conditional probability of firms adopting dual-class shares structures.

Column 1 of Table 8 reports the probit regression of the likelihood for a firm to adopt dual-class shares. As expected, the instrument variable is relevant. The industry structure of dual-class firms has a significant and positive on a firm's adoption of dual class structure. A firm registered in a state with higher anti-takeover index is also more likely to adopt this structure. The instrumented dual class dummy variable takes out any firm specific factors related to innovation and identify the causal effect of dual-class shares structures on firm innovation. The Wald Chi-square tests suggest that the instrumental variable of industry structure of dual-class shares has significant power in explaining dual-class phenomenon. In the second stage OLS regressions, dual-class dummy variable estimates are insignificant in Column 2 (patent counts) but positive and significant in Column 3 (citations per patents for a firm). Lambda or inverse Mills Ratio has a strong and negative coefficient estimates, suggesting that firms' adoption of dual-class shares is indeed endogenous. Other control variables have estimated coefficients largely consistent with the literature and prior findings in the paper.

Table 8
Endogeneity Test of Dual-Class Structure on Innovation. This table reports the endogeneity test results of the effects of dual-class shares on innovation productivity for the period from 1970 through 2006. We use Heckman selection regression where we regress firm innovation output in year $t+1$ on a dual-class dummy variable that equals one if a firm has dual-class shares in year t and zero otherwise, and simultaneously regression dual-class dummy on the instrument variables (industry mean of dual-class firms in past year, dilution of insiders at IPO year, and a state's takeover index) in the selection regression. The regressions control both firm and year fixed effects and cluster on firm level. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively using *t*-statistics for two-tailed tests. The t-values are reported in parentheses.

	Dual class dummy	$Ln(1+Pat)_{t+1}$	$Ln\left(1+\frac{Cit}{Pat}\right)_{t+1}$
	(1)	(2)	(3)
Industry mean of dual-class firm past 5 years	12.012***		
	[22.83]		
State anti-takeover index	0.524		
	[1.50]		
Predicted(Dual class dummy)		−0.0613	0.2328**
		[-1.31]	[2.28]
Lambda		−0.1080***	−0.2393***
		[-6.64]	[-6.16]
Q		0.0099***	0.0229***
		[3.79]	[4.80]
Ln(Firm age)		−0.2227***	−1.0807***
		[-8.62]	[-24.55]
Ln(Sales)		0.0735***	−1.009***
		[5.50]	[-4.91]
ROA		−0.0362	0.3187***
		[-1.36]	[4.83]
Tangibility		−0.0495	0.8829***
		[1.46]	[5.93]
Leverage		−0.1087***	−0.1499**
		[-2.94]	[-2.29]
HHI		−0.1001	−0.3886*
		[-0.98]	[-1.68]
R&D expenses/Assets		−0.0609	0.0435
		[-1.32]	[1.48]
Constant	−5.458***	2.1418***	5.0528***
	[45.23]	[12.21]	[24.67]
N	26385	26385	26385
adj. R-sq		0.05	0.07
Wald Chi-sq	531.90		
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

The two-stage IV regressions may not fully address the endogeneity problem related to the effect of dual-class structures on corporate innovation. However, the endogeneity should work against our empirical hypothesis since agency problem caused by dual-class shares suggests a negative effect on corporate innovation. The robust positive effect of dual-class structures on citations per patent reported in all the regressions suggests that the evidence we document is indeed not caused by endogeneity reasons.

5. Conclusion

There has been a proliferation of high-tech IPOs adopting dual-class share structures in US market and others as well. The phenomenon raises scrutiny among the academics and practitioners concerning whether insiders extract private benefits by utilizing dual-class shares to entrench themselves and expropriate minority shareholders. As such, dual-class share structures will result in a degradation of corporate governance in corporations. Our research attempts to reconcile this controversial trend by investigating the effects of dual-class share structures on corporate innovation. Dual-class structures are a double-edged sword for corporations. We document the positive role of dual-class share structures on corporate innovation in this research. The empirical analysis provides strong evidence that dual-class shares do not necessarily stifle innovation. On the contrary, dual-class structures help firms to produce impactful patents and creative innovation.

As a double-edged sword, the positive effect of dual-class structures on innovation prevails only when market disciplining force is effective. We show that dual-class structures have positive economic impact on corporate innovation in high-tech sectors, hard-to-innovate industries, in states with higher anti-takeover index or firms subject to greater equity dependence. Further the analysis with SOX as the policy shock on the corporate governance confirms the positive effect of dual-class structures on corporate innovations. Finally, the instrument variable regressions show robust results and rule out the possibility that our results are driven by endogeneity problems.

Overall, our research provides important insights on the increasing popularity of dual-class shares among high-tech companies. The positive effect of dual-class structures on corporations is a conditional phenomenon and the wide use of dual-class shares needs to be scrutinized. The policy implication is that dual-class share structure needs to be considered strategically in balancing agency cost and long-term effect on innovation activities. In general, firms need to focus on long-term competition capability rather than short-term earnings pressure alone.

Appendix A. Variable Definitions

Variable	Definition
Innovation measures	
Patent Counts	Patent counts are defined as number of patent applications filed in year *t* of each firm. Only patents that are later granted are included. The patent number is set to zero for companies that have no patent information available.
Citation Number	Citation number is defined as number of citations received by patent applications filed in year *t* of each firm. The citation number is corrected for the truncation bias in citation counts using the Hall et al. (2001) adjustment factor.
Control variables	
Ln(Asset)	The logarithm of the book value of total assets (AT from COMPUSTAT) measured at the end of fiscal year *t*.
Firm Age	The number of years from the firm's IPO year to year *t*.
ROA	Firm operating income before depreciation (OIBDP from COMPUSTAT) divided by the book value of total assets (AT), measured at the end of fiscal year *t*.
Tobin's Q	The market value of equity (PRCC_F × CSHO from COMPUSTAT) plus the book value of assets (AT) minus the book value of equity (CEQ from COMPUSTAT) minus balance sheet deferred taxes (TXDB from COMPUSTAT)] divided by the book value of assets (AT), measured at the end of fiscal year *t*.
Leverage	The book value of debt (DLTT + DLC from COMPUSTAT) divided by the book value of total assets (AT) measured at the end of fiscal year *t*.
PPE-to-Assets	The book value of property, plant and equipment (PPENT from COMPUSTAT) divided by the book value of total assets (AT) measured at the end of fiscal year *t*.
R&D Expense-to-Assets	Research and develop expenditure (XRD from COMPUSTAT) divided by the book value of assets (AT), measured at the end of fiscal year *t*. Missing R&D expenses are replaced by zero.
Herfindahl Index	Herfindahl index of the 3-digit SIC industry of each firm measured at the end of fiscal year *t* based on sales.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.econmod.2020.06.017.

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