Management Quality and Innovation in Entrepreneurial Firms

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Abstract

We make use of hand-collected data on the quality and reputation of the management teams of a large sample of venture-backed entrepreneurial firms undertaking initial public offerings (IPOs) to address two research questions: How does the human capital of a firm's top management team ("management quality") affect the quantity and quality of innovation undertaken by it? Second, what are the effects of the pre-IPO innovativeness of a firm and its management quality on the characteristics of its IPO and its post-IPO operating performance? We hypothesize that higher quality management teams hire better scientists and other researchers; invest in more innovative projects; and manage these projects more ably, leading to higher innovation productivity. Consistent with this, we show in the first part of our analysis using ordinary least squares and instrumental variable analyses that firms with higher management quality exhibit higher innovation productivity in the years immediately before and after their IPOs. The above results hold for both the quantity (number of patents) and quality (citations per patent) of innovation. In the second part of our analysis, we find that firms with greater pre-IPO innovativeness are associated with a larger number of anti-takeover provisions in their corporate charter (determined at IPO), higher IPO valuations, younger age at IPO, and better post-IPO operating performance. Further, we find that the above effects are enhanced if innovative firms are managed by teams of higher management quality.

1. Introduction

The importance of innovation for the long-run success and competitive advantage of firms is well known since Schumpeter and has been discussed extensively in the literature (see, e.g., Porter (1992)). However, the precise drivers of innovation are less well understood. It has been argued that, since innovation is a process involving great uncertainty and high risk of failure (see, e.g., Holmstrom (1989)), the drivers of innovation may differ significantly from those of more routine tasks. Thus, Manso (2011) argues that motivating innovation needs significant tolerance for failure in the short run and reward for success in the long run. The objective of this paper is to analyze an important factor that may drive corporate innovation, namely, the human capital or "quality" of a firm's top management team, for the first time in the literature. We first analyze how the management quality of entrepreneurial firms affects the quantity and quality of product market innovation undertaken by them. We then go on to analyze how the innovativeness of entrepreneurial firms prior to going public, together with management quality, affects various aspects of their initial public offering (IPO): the number of anti-takeover provisions (ATPs) in their corporate charters (usually decided at the time of going public); IPO firm valuation; firm age at IPO; and post-IPO operating performance.

The quality and reputation of a firm's management team may affect its innovation productivity in several ways. First, firms with higher management quality are likely to hire higher quality employees (scientists and engineers) who are likely to be more innovative. Second, higher quality management teams are likely to select projects with greater innovation productivity. Third, higher quality managers may be able to manage their researchers (scientists and engineers) better (e.g., by exhibiting greater failure tolerance: see Manso (2011)), so that their firm's innovation productivity is greater. Based on the above reasoning, we conjecture that entrepreneurial firms with higher management quality will be more innovative both before and after their IPOs, as measured by the quantity as well as the quality of innovation.

The innovativeness and management quality of a firm may also affect the number of ATPs in its corporate charter, which is decided upon at the time of going public. The role of ATPs in a firm's corporate charter and their effect on firm performance have recently become controversial: see, e.g., Chemmanur, Paeglis, and Simonyan (2011) and Johnson, Karpoff, and Yi (2013). On the one hand, theoretical models such as Chemmanur and Jiao (2012) have argued that ATPs may allow firm managers to create greater long-run value by mitigating the problem of corporate myopia. Under this "long-term value creation" hypothesis, we would expect firms that are more innovative pre-IPO to incorporate a larger number of ATPs in their corporate charters. Since higher quality managers are likely to be able to create greater long-run value, we would expect the joint effect of pre-IPO innovativeness and management quality on the number of ATPs to be positive as well. On the other hand, purely agency theoretic models (see, e.g., Grossman and Hart (1988)) imply that ATPs may merely entrench incumbent firm management by reducing the probability of takeovers by rival management teams, thereby insulating managers from the discipline imposed by the market for corporate control. This means that a larger number of ATPs will allow managers to exert less effort in running their firms. Consequently, under this "management entrenchment" hypothesis, founders of more innovative firms will incorporate a smaller number of ATPs in their corporate charters in order to maximize shareholders' value. Further, assuming that higher quality managers incur a smaller cost of effort, we would expect the joint effect of pre-IPO innovation and management quality on the number of ATPs to be negative as well.

The innovativeness and management quality of a firm may also affect its valuation and age at IPO as well as post-IPO operating performance. Assuming that firms with greater pre-IPO innovation productivity have access to a larger number of positive NPV projects, we would expect such firms to generate larger long-run cash flows (better post-IPO operating performance) and therefore higher IPO valuations (since IPO valuation is simply the present value of future cash flows). Since going public is costly, but has the benefit of allowing a firm to raise external capital on more advantageous terms compared to private equity financing, a private firm will go public when the benefit of going public exceeds the cost of doing so. This means that firms with greater pre-IPO innovation productivity (with a larger number of positive NPV projects to be funded) will go public earlier, since such firms reach the tipping point where the benefit of going public exceeds the cost at a younger age. Assuming that a firm with a given innovation productivity will generate larger long-run cash flows if managed by a higher quality management team, we expect the joint effect of greater pre-IPO innovation productivity and higher management quality to result in better post-IPO operating performance, higher IPO valuation, and younger age at IPO.

We test the above hypotheses using data on a sample of venture-backed firms going public between 1993 and 2004. We make use of measures of management quality developed by Chemmanur and Paeglis (2005) and Chemmanur, Paeglis, and Simonyan (2011). Data on management quality and ATPs in the charters of firms going public were hand-collected from IPO prospectuses.[1] We make use of the information about the number of patents granted to a firm and the number of citations received by each patent obtained from the National Bureau of Economic Research (NBER) Patent Citation database as our main measures of firm innovation. Specifically, patent counts measure the quantity of innovation and citations per patent measure the quality of innovation. Our use of patenting to capture firms' innovation output has become standard in the innovation literature (e.g., Aghion, Van Reenen, and Zingales (2013), Nanda and Rhodes-Kropf (2013), Seru (2014)).

We confine our study to venture-backed entrepreneurial firms for two reasons. First, venture-backed firms typically belong to industries (e.g., software, pharmaceutical, biotechnology) where innovation is an important component of firm value.[2] Second, since the existing literature has documented that venture backing has an important effect on firm innovation (see, e.g., Tian and Wang, 2014) and the focus of this study is on the effect of management quality on innovation, we are able to eliminate the confounding effects of venture backing by confining our study to firms that are similar to each other in terms of venture backing.

Our empirical findings can be summarized as follows. In the first part of our analysis, we find from our ordinary least squares (OLS) regressions that firms with higher management quality (as measured by our management quality factor) have greater innovation productivity both in terms of the

[1] We study 19 ATPs at the firm level: see Appendix A of Chemmanur, Paeglis, and Simonyan (2011) for a detailed description of these.

[2] Since most of the firms in our non-venture-backed IPO sub-sample are in industries that are not innovation-intensive, we do not find significant variation in patents and citations per patent in this sub-sample.

quantity (number of patents) and the quality (citations per patent) of innovation. Our OLS regressions of pre- and post-IPO innovation variables on individual management quality proxies indicate that top management team size and the proportion of the top management team with an MBA degree are positively related to the quantity and quality of innovation undertaken by a firm, while the average tenure of the members of the top management team is negatively related. The above relationship between management quality and innovation holds for innovation pre-IPO (as measured over the two years before IPO) and post-IPO (as measured over the IPO year and the two years after IPO).

It may be argued that management quality is potentially endogenous, since higher quality firms are more likely to attract higher quality managers. To control for this potential endogeneity of management quality, we conduct an instrumental variable analysis of the effect of management quality on innovation. We use the percentage of the population with a bachelor's degree or higher in the same three-digit zip code area as an entrepreneurial firm's headquarters as our instrument for management quality. The findings of our instrumental variable analysis are similar to those of our OLS regression analysis discussed earlier, indicating that our results on the relationship between management quality and innovation (both quantity and quality) are robust to controlling for the potential endogeneity of management quality.

In the second part of our analysis, we find the following. First, firms that are more innovative pre-IPO (as measured by either the quantity or the quality of innovation) are likely to have a larger number of ATPs in their corporate charters at IPO. Second, the joint effect of pre-IPO innovativeness and management quality on the number of ATPs in a firm's corporate charter at IPO is also positive. In other words, when we divide our sample into four groups, those with high or low pre-IPO innovation, with each group sub-divided into firms with high or low management quality, we find that those with high pre-IPO innovation and high management quality have the largest number of ATPs on average compared to firms belonging to the other three groups. Our findings in this part of our analysis provide support for the long-term value creation hypothesis and contradict the management entrenchment hypothesis.

In the third part of our analysis, we find the following. First, firms that are more innovative pre-IPO (as measured by either the quantity or the quality of innovation) are awarded higher valuations by the IPO market as measured either at the IPO offer price or at the closing price on the first day of trading. We find that the joint effect of pre-IPO innovation and management quality on firm valuation at IPO is also positive. Second, firms that are more innovative pre-IPO (as measured by either the quantity or the quality of innovation) go public at a younger age. Further, the joint effect of pre-IPO innovation and management quality on a firm's age at IPO is also negative. Third, firms that are more innovative pre-IPO (as measured by either the quantity or the quality of innovation) experience greater improvements in operating performance in the years immediately after IPO (compared to the pre-IPO year). The joint effect of pre-IPO innovation and management quality on the improvements in post-IPO operating performance is also positive. Our results in this part of the paper indicate that firms with greater pre-IPO innovativeness are able to translate it into a larger growth in post-IPO operating cash flows. Further, IPO market investors, anticipating the above, award such firms higher valuations and allow them to go public earlier.

Our paper contributes to several strands in the theoretical and empirical literature. The first is the theoretical and empirical literature on the management of innovation. The existing theoretical literature has focused on the optimal organizational form of innovative activity in a setting of incomplete contracting (e.g., Aghion and Tirole (1994) and Fulghieri and Sevilir (2009)) or the nature of contracting between firm managers and researchers (e.g., Manso (2011)). The empirical literature analyzing how various firm and industry characteristics affect managerial incentives for investing in innovation is also related to our paper. Some examples of this literature are Ederer and Manso (2013), who conduct a controlled laboratory experiment; Azoulay, Graff Zivin, and Manso (2011), who exploit key differences in funding streams within the academic life sciences; Lerner, Sorensen, and Stromberg (2011), who study the effect of private versus public equity ownership; and Aghion, Van Reenen, and Zingales (2013), who study the effect of a larger institutional ownership. Our paper contributes to this literature by showing, for the first time in the literature, that the human capital of a firm's top management team may also be an important factor that affects the quantity and quality of the innovative activities undertaken by the firm.

A number of papers have also analyzed the role played by venture capitalists in motivating the innovation productivity of firms backed by them, and the channels through which venture capitalists may influence this productivity. Some examples of this literature are Kortum and Lerner (2000), Tian and Wang (2014), and Chemmanur, Loutskina, and Tian (2014). While for the reasons discussed above, we use a sample of venture-backed entrepreneurial firms for our analysis, unlike the above literature our focus here is not on the effect of venture backing on innovation but rather on how the human capital of a firm's top management team affects its innovation activities.

Our paper is also related to the theoretical and empirical literature on the role of human capital of employees and management in affecting firm performance. The importance of the human capital of employees in affecting firm performance has been hypothesized in the seminal theoretical work of Becker (1962). The empirical papers in this literature closest to our paper are Chemmanur and Paeglis (2005), who study how the management quality of a firm affects its IPO characteristics, and Chemmanur, Paeglis, and Simonyan (2011), who study the relationship between the management quality of a firm and the ATPs in its corporate charter at IPO. Neither of these papers analyzes the relationship between the quality of a firm's top management team and the innovative activities undertaken by it, which is our focus here. There has also been a literature on how CEO characteristics affect innovation: see, e.g., Hirshleifer, Low, and Teoh (2012), who find that overconfident CEOs invest more in R&D and obtain more patents and citations, and Barker and Mueller (2002), who relate CEO characteristics and R&D spending. Unlike this literature, our focus here is on how the quality of a firm's entire management team affects innovation.[3]

The literature on how the ATPs in a firm's corporate charter affect its performance in general and its innovation productivity in particular is also related to our paper. The evidence in this literature has been mixed as it provides contradictory findings on the effect of ATPs on future performance. In an early paper,

[3] The broader literature on the effect of management quality on financial policies and performance is also indirectly related to our paper: e.g., Bertrand and Schoar (2003) find that manager fixed effects explain some of the heterogeneity in investment, financial, and organizational practices of seasoned firms. This paper is also related to the growing literature in organizational economics linking the importance of agents across and within organizations. For example, Bandiera, Barankay, and Rasul (2010) find that workers are more productive when they work with higher ability co-workers and less productive when they work with lower ability co-workers (see also Bandiera, Barankay, and Rasul (2005)).

Field and Karpoff (2002) argued that ATPs play a role in entrenching firms' managers. A more recent paper by Chemmanur, Paeglis, and Simonyan (2011) shows that firms with higher management quality have a larger number of ATPs in their corporate charters and have better post-IPO operating performance. The papers analyzing the relationship between ATPs and innovation are also related to our study. Atanassov (2013) finds that state anti-takeover laws stifle innovation, while Chemmanur and Tian (2013) show that firm-level ATPs spur innovation. In contrast to the above literature, where the focus is on how ATPs affect a firm's performance (and innovation in particular), our focus in this paper is on how the innovativeness of a firm prior to its going public affects the number of ATPs in its corporate charter.[4]

The rest of this paper is organized as follows. Section 2 summarizes the relevant theory and develops testable hypotheses. Section 3 describes our data. Section 4 discusses our measures of management quality and product market innovation, as well as other measures of firm quality and internal governance. Section 5 presents our empirical tests and results. Section 6 concludes.

2. Theory and Hypotheses Development

2.1. Management Quality and Pre- and Post-IPO Innovation

In this section, we develop hypotheses to examine the relationship between management quality and innovation both before and after the IPO. We hypothesize that firms with higher management quality (i.e., with management teams having greater human capital) are likely to select higher quality employees (scientists and engineers), who, in turn, are likely to be more innovative (even if firm managers themselves are not directly engaged in innovation activities). Further, Chemmanur and Jiao (2012) argue that more talented managers have the ability to create long-run value by investing in long-term rather than short-term projects. This implies that higher quality managers will select long-term projects (i.e., more innovative projects in our setting). Finally, Manso (2011) has argued that an important variable in

[4] To the extent that, in the second part of our paper, we analyze the joint effect of management quality and innovation on a firm's IPO characteristics, our paper is also distantly related to Chemmanur, Simonyan, and Tehranian (2013), who study how management quality affects IPO characteristics in venture-backed firms. The broader theoretical and empirical literature on IPOs is also related to our paper: see Ritter and Welch (2002) for a review.

encouraging innovation is failure tolerance. While Manso (2011) does not distinguish between higher and lower quality firm management teams, if we add the additional assumption to the Manso (2011) setting that higher quality managers are also more failure tolerant, then it will be the case that firms that have higher quality management teams will also have better innovation productivity. In other words, firms with higher quality management teams will be able to manage their researchers (scientists and engineers) better (greater failure tolerance may be only one example of this) so that their firms' innovation productivity is greater. Thus, as implied by each of the above three arguments, our first hypothesis here is that firms with higher management quality will be more innovative both before and after the IPO (measured by the quantity as well as the quality of innovation) (**H1**).

2.2. Pre-IPO Innovation, Management Quality, and Anti-Takeover Provisions (ATPs)

In this section, we first delve into the question of whether more innovative firms choose corporate charters with more ATPs at the time of their IPOs (usually, this is the first time a firm decides on a comprehensive set of provisions to incorporate in its corporate charter). The corporate myopia model of Stein (1989) and the theoretical model of Chemmanur and Jiao (2012) imply that more innovative firms (those with a larger number of long-run projects available to them) can benefit to a greater extent from more ATPs, since they can be insulated to a greater extent from the stock market, thus obtaining the time required to bring their longer term (more innovative) projects to fruition. The theoretical model of Manso (2011) also suggests that more innovative firms may place more ATPs in their corporate charters, since this may be one way of increasing their failure tolerance (even after IPO), given that, by reducing the probability of takeovers, ATPs allow incumbent firm management more time to bring their innovative projects to fruition. Thus, we hypothesize that firms that are more innovative (as measured by pre-IPO innovation) will have more ATPs in their corporate charters at IPO (**H2A**). We will refer to this hypothesis as the "long-term value creation" hypothesis.

In contrast to the above arguments, moral hazard models (e.g., the seminal works of Grossman and Hart (1988) and Harris and Raviv (1988, 1989)) suggest that managers who are not properly monitored will shirk and will invest suboptimally in short-term projects (characterized by quicker and more certain returns) in order to enjoy private benefits of control. In such a setting, hostile takeovers serve as an effective disciplining mechanism to mitigate this moral hazard problem and encourage innovation effort, thus increasing firm value. Such arguments imply that ATPs (such as dual-class share structures) serve merely to entrench incumbent firm management, thus reducing the effectiveness of equity market discipline on them and consequently reducing corporate innovation (potentially lowering firm value).[5] Under this line of reasoning, the founders of more innovative firms (as measured by their pre-IPO innovation) will incorporate a smaller number of ATPs in their corporate charters at IPO in equilibrium, provided that they wish to maximize shareholder value after IPO (**H2B**). We will refer to this hypothesis as the "management entrenchment" hypothesis.

Next, we examine the joint effect of pre-IPO innovativeness and management quality of a firm in determining the number of ATPs in its corporate charter. The arguments made by Chemmanur and Jiao (2012) imply that for a given level of innovativeness, higher management quality firms will have a larger number of ATPs in their corporate charters. This is because, in their setting, management quality is a double-edged sword: while higher quality firm managers can create long-run value by investing in long-run projects and working harder to implement them, lower quality managers (with higher effort costs) have less ability to create such long-run value and instead are more likely to shirk while using ATPs as a shield against takeovers. This means that, for a given level of firm innovativeness, a higher management quality is associated with greater value-creating benefits of including a larger number of ATPs in the firm's charter.[6] Further, as we discussed earlier, firms that are more innovative can be expected to have a larger number of ATPs in their corporate charters under the long-term value creation hypothesis. Given

[5] The above models consider a setting where the incumbent manager of a firm (large shareholder) obtains not only cash flow or "security" benefits (arising from his equity ownership in the firm) but also private benefits from being in control; outside shareholders receive only security benefits. These models imply that ATPs are potentially value reducing, since they reduce the chance of takeovers by rival management teams who can increase the cash flows to current shareholders by managing the firm better than does the incumbent. Thus, under the above theories, ATPs are inefficient, and the only role of such provisions is to entrench existing management and reduce the chance of losing their benefits of control. See also Cary (1969) and Williamson (1975), who made earlier, more informal, arguments that ATPs act primarily to entrench incumbent management.

[6] Similar implications flow from the model of Manso (2011), if we assume that higher quality managers are better at implementing innovative projects and will use ATPs in a firm's corporate charter to a greater extent to increase their firm's failure tolerance.

that the individual effects of pre-IPO innovativeness and management quality on the number of ATPs in a firm's corporate charter are positive under the long-term value creation hypothesis, we expect that the joint effect of management quality and innovation on the number of ATPs included in a firm's corporate charter at IPO will also be positive (**H3A**).

In contrast to the above arguments, the agency-theoretical models discussed earlier in this section do not incorporate a value-enhancing role for ATPs in a firm's corporate charter. In other words, ATPs only serve to reduce the disciplining effect of takeovers, thus allowing firm management to shirk to a greater extent. Thus, if we add the additional assumption that the effort cost is smaller for higher quality managers (so their benefit from shirking is smaller), then, for a given level of firm innovativeness, the number of ATPs included in a firm's corporate charter will be decreasing in its management quality. Further, as we discussed earlier, firms that are more innovative can be expected to have a smaller number of ATPs in their corporate charters under the management entrenchment hypothesis. Given that the individual effects of pre-IPO innovation and management quality on the number of ATPs in a firm's corporate charter are negative under the management entrenchment hypothesis, we expect that the joint effect of management quality and innovation on the number of ATPs included in a firm's corporate charter at IPO will also be negative (**H3B**).

If we divide firms going public based on management quality (above-median versus below-median management quality) and pre-IPO innovation (above-median versus below-median pre-IPO innovation), hypotheses **H3A** and **H3B** have clear predictions for firms falling in the four quadrants: high management quality and high pre-IPO innovation (Q1), high management quality and low pre-IPO innovation (Q2), low management quality and high pre-IPO innovation (Q3), and low management quality and low pre-IPO innovation (Q4). Hypothesis **H3A** predicts that firms belonging to quadrant Q1 will have a larger number of ATPs than the average number of ATPs for the firms belonging to the other three quadrants. Hypothesis **H3B** predicts the opposite.

2.3. Pre-IPO Innovation, Management Quality, and the IPO Market

In this section, we develop hypotheses regarding the effect of management quality and pre-IPO innovation on two important variables related to the IPO market: IPO firm valuation and firm age at IPO.

2.3.1. Pre-IPO Innovation, Management Quality, and Firm Valuation at IPO

We first develop hypotheses regarding the effect of pre-IPO innovation on IPO valuation. If a firm is perceived by participants in the IPO market as being more innovative (as measured by the quantity and quality of pre-IPO innovation), they may predict that, *ceteris paribus*, it will have better future operating performance on average (a hypothesis we directly test separately later). Since the value of a firm in a symmetric information setting is simply the present value of its future cash flows, IPO valuation (and immediate post-IPO secondary market valuation) will be greater for firms that are more innovative pre-IPO. Further, IPO market participants may view pre-IPO innovation as a signal of future innovation productivity as well (in a setting of information asymmetry between firm insiders and outsiders), further increasing their expectation of the firm's future cash flow performance and therefore its IPO valuation. For the above reasons, we hypothesize a positive relationship between pre-IPO innovation and IPO valuation (**H4**).

We next examine the joint effect of pre-IPO innovation and management quality on IPO firm valuation. If we assume that higher quality managers can implement their firms' innovative projects better so that they translate into higher cash flows, then we would expect that, for a given level of firm innovativeness, a higher management quality will be associated with a higher IPO (and immediate post-IPO) valuation. Further, as we discussed earlier, firms that are more innovative will have greater IPO valuations (for a given management quality). Given that the individual effects of pre-IPO innovation and management quality on IPO firm valuation can be expected to be positive, we expect their joint effect on IPO valuation to be positive as well (**H5**).[7] This implies that firms belonging to quadrant Q1 (using the

[7] Given that Chemmanur, Simonyan, and Tehranian (2013) have shown that there is a positive association between management quality and IPO firm valuation and a negative association between management quality and firm age at IPO, we do not study the direct effect of management quality on these two IPO variables here. Rather, our focus here

definition of firm quadrants specified in section 2.2) will have higher IPO valuations than the average IPO valuation of firms belonging to the other three quadrants.

2.3.2. Pre-IPO Innovation, Management Quality, and Firm Age at IPO

We now turn to the effect of pre-IPO innovation and management quality on firm age at IPO. We first analyze the direct effect of the pre-IPO innovation of a firm on the age at which it goes public. There are many theoretical models of the going public decisions of firms, two of which have strong predictions for the relationship between pre-IPO innovation and firm age at IPO. The first model is that of Clementi (2002), developed in a setting of symmetric information. Clementi (2002) builds a dynamic model of going public decision in which the firm operates in an industry characterized by decreasing returns to scale and going public is costly. Prior to going public, a borrowing (financial) constraint keeps the firm's scale of production at a suboptimal level. In the above setting, a sudden positive productivity shock (resulting in a new set of positive NPV projects becoming available to the firm) has the effect of widening the gap between the optimal and the actual scale of the firm, so that the marginal benefit of expanding operations by going public outweighs the marginal cost of doing so, so the firm goes public at this time. If we assume in the above setting that greater innovation productivity (pre-IPO) is associated with a larger number of positive NPV projects, then the above reasoning implies that more innovative firms are likely to go public at an earlier age (since such firms reach the tipping point where the benefits of going public exceed the cost at a younger age).

A second model that considers the effect of asymmetric information on a firm's going public decision is Chemmanur and Fulghieri (1999), who model a firm's going public decision in a setting where insiders have private information about firm value, but outside investors in the IPO market can produce information about the firm at a cost. In their setting, outsiders' cost of producing information about the firm declines over time (as the firms establish a track record) and firms go public when this cost falls below a certain threshold value. Thus, assuming that firms with greater pre-IPO innovativeness

is on how management quality affects the relationship between pre-IPO innovation and IPO firm valuation and on how management quality affects the relationship between pre-IPO innovation and firm age at IPO.

are associated with lower costs of information production for outsiders (at any given age), such firms can be expected to go public earlier.[8, 9] Thus the implication of both above models is that firms that are more innovative will go public at a younger age, *ceteris paribus* (**H6**).[10]

We now examine the joint effect of pre-IPO innovation and management quality on a firm's age at IPO. In the Clementi (2002) setting discussed earlier, we now add the assumption that a given innovation, if implemented by a higher quality management team, will have a greater NPV. This implies that firms of a given pre-IPO innovativeness with higher management quality will have a greater marginal benefit from expanding operations by going public. This further implies that such firms are more likely to go public at an earlier age (since such firm reach the tipping point where the benefit of going public exceeds the cost at a younger age). Similarly, in the model of Chemmanur and Fulghieri (1999), if we assume that for a given level of innovativeness (and at any given age) firms with higher management quality are associated with a lower cost of information production for outsiders, the implication is that such firms will go public earlier. Given that the individual effects of pre-IPO innovation and management quality on firm age at IPO can be expected to be negative, we expect their joint effect on firm age at IPO to be negative as well (**H7**). This implies that firms belonging to quadrant Q1 (as defined in section 2.2) will have a younger age at IPO than the average age for firms belonging to the other three quadrants.

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[8] If a firm raises capital by going public, it faces duplication in outside investors' information production costs (ultimately, these information production costs are borne by the firm through a lower share price), since it needs to convince a number of investors that the firm's projects are worth investing in. In contrast, if it raises capital privately (such as from a venture capitalist), there is no such duplication in information production, but the private financier charges a risk premium over his cost of funds, since he is taking an undiversified position in the firm. In such a setting, when potential IPO market investors' information production costs are large, the aggregate cost of duplication in outsiders' information production outweighs the premium demanded by private financiers, and the firm chooses not to go public; if, however, the outsiders' cost of information production falls for any reason (for example, due to the firm developing a track record of innovation), so that the aggregate cost of duplication in outsiders' information production is outweighed by the premium demanded by private financiers, then the firm decides to go public.

[9] Since, in equilibrium, outsiders' information production costs are borne by the firm through a lower IPO share price, the Chemmanur and Fulghieri (1999) model also predicts that firms that are more innovative pre-IPO will obtain higher IPO valuations, since IPO market investors' evaluation costs will be lower for such firms.

[10] Two models that explicitly incorporate the effect of going public on the innovation productivity of a firm are Ferreira, Manso, and Silva (2012) and Spiegel and Tookes (2010). Both models predict that firms will be more innovative pre-IPO rather than post-IPO, though for reasons different from each other. However, these two models do not seem to have unambiguous predictions for the relationship between the pre-IPO innovation productivity of a firm and the timing of its IPO (i.e., its age at IPO).

2.4. Pre-IPO Innovation, Management Quality, and Post-IPO Operating Performance

We first examine the relationship between pre-IPO innovation and post-IPO operating performance. Assuming that more innovative firms are associated with a larger number of positive NPV projects, such firms will be associated with better operating performance as these projects are implemented over time. However, one confounding factor in the relationship between pre-IPO innovation and post-IPO operating performance is a firm's age at IPO. As we conjectured in section 2.3.2, firms that are more innovative may be able to go public at a younger age, at which point their profitability is likely to be lower than that of firms going public at a later stage. Thus, if this second effect (firm age at IPO) dominates, pre-IPO innovation will be negatively related to the *level* of the firm's long-term post-IPO operating performance. One can separate out the effect of pre-IPO innovation alone on operating performance by studying the *changes* in operating performance after IPO: we expect firms with greater pre-IPO innovation to experience unambiguously larger improvements in operating performance in the years immediately after IPO (**H8**).

We now examine the joint effect of pre-IPO innovation and management quality on a firm's post-IPO operating performance. For the reasons discussed above, we focus only on changes in post-IPO operating performance. As we argued in section 2.3.1, if we assume that higher quality managers can implement their firms' innovative projects better so that they translate into higher cash flows, then we would expect that, for a given level of pre-IPO innovation, a higher management quality will be associated with larger improvements in operating performance in the years immediately after IPO. Given that the individual effects of pre-IPO innovation and management quality on the changes in post-IPO operating performance can be expected to be positive, we expect their joint effect on the changes in post-IPO operating performance to be positive as well (**H9**). This implies that firms belonging to quadrant Q1 (using the definition given in section 2.2) will have larger improvements in operating performance compared to the firms belonging to the other three quadrants.

3. Data and Sample Selection

The list of U.S. IPOs in 1993-2004 comes from the SDC/Platinum Global New Issues database. We excluded real estate investment trusts (REITs), closed-end funds, unit IPOs, spin-offs, equity carve-outs, financial firms (with SIC codes between 6000 and 6999), foreign firms, and former leveraged buy-outs (LBO). We further eliminated nine firms which did not have management quality information available in their prospectuses. We merged this IPO list with VentureXpert to consistently identify venture-backed IPO firms. Thus, our final sample consists of 1,851 venture-backed IPO firms.

The information on ATPs was hand-collected from "Capital Stock" section of IPO prospectuses.[11] Information on various management quality proxies, such as team size, education, prior managerial experience, functional expertise, and tenure of management team members was hand-collected from the "Management" section of IPO prospectuses. The data necessary to calculate the CEO dominance variable came from the "Executive Compensation" section of the prospectuses. Information on internal governance mechanisms (such as CEO/Chairman-of-the-board duality, proportion of outside directors, and insider stock ownership) came from the prospectuses as well. IPO prospectuses were obtained from the Thomson Financial database. Information on the institutional shareholdings was obtained by searching 13F and 13F-E filings. Accounting data came from Compustat and stock price data came from CRSP. Finally, innovation date came from the NBER Patent Citation database.

4. Measures of Management Quality, Product Market Innovation, and Firm Quality

4.1. Measures of Management Quality and Reputation

We follow Chemmanur and Paeglis (2005) and Chemmanur, Paeglis, and Simonyan (2011) in constructing our management quality measures. Management quality is affected by the amount of human and knowledge resources (including education and experience) available to the management team. Our first proxy of management quality, the management team size, measures the amount of human resources available. It is the number of executive officers with a title of a vice president or higher on the team

[11] See Chemmanur, Paeglis, and Simonyan (2011) for details.

(TSIZE). The next two proxies measure the education level of managers. Our second proxy of management quality is the percentage of management team members with an MBA degree (PMBA) and the third proxy is the percentage of management team members who are Certified Public Accountants (PCPA). The greater the percentages of MBAs and CPAs on the management team, the greater its quality.

We measure prior managerial experience of management team members by using the following two proxies. Our fourth proxy is the percentage of managers who have served as executive officers at other firms prior to joining the IPO firm (PFTEAM) and our fifth proxy is the percentage of managers who were partners at law or accounting firms prior to joining the IPO firm (PLAWACC). Clearly, the greater the percentage of management team members with prior managerial experience (including experience in the areas of law and accounting) the greater the management team quality.

Our sixth proxy of management quality is the percentage of team members with core functional expertise, namely, the percentage of team members holding positions in the areas of operations and production, R&D, sales and marketing, and finance (PCORE). The greater the percentage of team members with core functional expertise the greater the management quality.

Our seventh proxy of management quality is CEO dominance (FCEO). On the one hand, a strong CEO may improve the cohesion of the management team. On the other hand, a strong-willed and dominating CEO may severely diminish possible contributions from other team members. Thus, while we believe that CEO dominance is an important measure of team quality, we are agnostic about the direction of the expected impact (positive or negative) of this measure of management quality. Our measure of CEO dominance is the ratio of CEO salary and bonus to the average salary and bonus of other team members listed in the executive compensation section of the prospectus in the fiscal year prior to the IPO. Assuming that CEOs have a substantial influence over their own pay and nearly total influence over their subordinates' pay, this measure reflects the gap between the CEO's assessment of his own worth to the firm and his assessment of other team members' worth, and is thus a good measure of CEO dominance.[12]

[12] Similar measures have also been used in the strategy and organizational behavior literature to study the effect of management team quality on firm performance: see, e.g., D'Aveni (1990) and Hambrick and D'Aveni (1992), who use such measures to study the deterioration of management team quality around bankruptcies.

Our eighth proxy of management quality measures the reputation of management team members in the business community. It is the number of other firms' corporate boards that team members sit on (BOARDS). While the measures discussed above also partially capture management team reputation, this proxy is a better representation of the reputation and visibility of managers in the business community. The greater the value of BOARDS, the greater the quality and reputation of a firm's management team.

Our last two proxies of management quality measure the degree of uniformity or heterogeneity in the tenures of management team members. Our ninth proxy of management quality is the average tenure of team members (TENURE), defined as the average number of years that team members have been with the firm.[13] Greater average tenure may indicate shared experiences and cohesion and thus lower costs of interaction between team members. However, longer tenures may also result in complacency and rigidity in team interactions. Thus, we are agnostic about the direction of the expected impact (positive or negative) of this measure of management quality. An ideal management team would have members from different cohorts, which would ensure an inflow of new ideas and perspectives. Further, a higher management quality would be associated with greater dispersion in such tenures. Therefore, we use the heterogeneity in management team tenures (TENHET) as our tenth management quality proxy. It is defined as the coefficient of variation of management team members' tenures.

4.2. Common Factor Analysis of Management Quality Variables

Although the individual management quality proxies discussed above are expected to measure management quality and reputation, they may each have unique limitations in capturing the underlying unobservable construct. Therefore, we use common factor analysis to construct a single factor for management quality that will capture the variation common to the observable measures of management quality and reputation discussed above.[14] In order to ensure that this single factor captures only the effect

[13] In our empirical tests, we have also used the median team tenure instead of the average team tenure. The results were similar.

[14] Several papers in the empirical finance and accounting literature make use of factor analysis to isolate the unobservable construct underlying several proxy variables. See, e.g., Gaver and Gaver (1993) and Guay (1999), who make use of factor analysis to study the size of a firm's investment opportunity set.

of management quality and not that of other variables such as firm size, firm age, industry characteristics, we use firm-size-, firm-age-, and industry-dummies-adjusted individual management quality proxies to extract the common factor.[15] Thus, our management quality factor score (MQF) is constructed using firm-size-, firm-age-, and industry-dummies-adjusted TSIZE, MBA, FTEAM, CORE, LAWACC, CPA, FCEO, and BOARDS. These variables refer, respectively, to the management team size, the number of management team members with MBA degrees, the number of management team members with prior managerial experience, the number of management team members with core functional expertise, the number of management team members with prior experience as law and accounting partners, the number of management team members who are CPAs, CEO dominance, and the number of other firms' corporate boards that management team members sit on.

We exclude TENURE and TENHET from the construction of the above common factor since these two proxies have negative factor loadings and negative scoring coefficients if included in the common factor analysis. The interpretation of our common management quality factor becomes problematic when some individual management quality proxies have positive scoring coefficients and others have negative scoring coefficients. Therefore, we restrict our common factor analysis to the first eight management quality proxies, since they have positive factor loadings and positive scoring coefficients when included in the common factor analysis. We then use TENURE and TENHET as control variables in our multivariate regressions.[16]

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[15] We adjust individual management quality proxies for firm size, firm age, and industry characteristics by regressing those management quality proxies on firm size, firm age, and 2-digit SIC code industry dummies, and take the residuals of such regressions (in other words, the variation in individual management quality proxies not explained by firm size, firm age, or industry characteristics) to be our firm-size-, firm-age-, and industry-dummies-adjusted individual management quality proxies.

[16] Negative factor loadings and negative scoring coefficients of TENURE and TENHET are due to negative correlations that these two proxies have with other management quality variables. For example, the correlation between TENURE (TENHET) and the percentage of management team members with prior managerial experience at other firms (PFTEAM) is -0.45 (-0.12) and the correlation between TENURE (TENHET) and the percentage of management team members with MBA degrees (PMBA) is -0.12 (-0.04). Indeed, firms that have management teams with longer average tenures are more likely to develop their managers internally, rather than to hire them from outside, and consequently such managers are less likely to have prior managerial experience at other firms. Similarly, managers who have longer average tenures with their firms are more likely to acquire their managerial skills internally, rather than externally at an educational institution.

Table 1 presents the results of our common factor analysis. Panel A of Table 1 presents the starting communalities of eight management quality proxies (for MQF factor described above), estimated as the squared multiple correlations obtained from regressing each management quality proxy on the remaining management quality proxies used in common factor analysis. Panel B of Table 1 presents the eigenvalues of the reduced correlation matrices. As suggested by Harman (1976), the number of factors necessary to approximate the original correlations among individual measures is equal to the number of summed eigenvalues necessary to exceed the sum of communalities. The eigenvalue of the first factor in our common factor analysis of MQF is 1.72 and it is larger than the sum of communalities of 1.55. This suggests that the MQF factor parsimoniously explains the intercorrelations between individual management quality proxies. Panel C of Table 1 presents the correlations between the MQF factor and the eight management quality proxies, respectively, while Panel D of Table 1 provides the summary statistics of the MQF factor.

4.3. Measures of Product Market Innovation

Following the innovation literature, we use patent-based metrics to capture firm innovativeness. We obtain information on entrepreneurial firm's patenting from the NBER Patent Citation database (see Hall, Jaffe, and Trajtenberg (2001) for details). The database provides detailed information on more than three million patents granted by the USPTO from 1976 to 2006, including patent assignee names, the number of citations received by each patent, and a patent's application as well as grant year. The span of the innovation data limits our ability to expand our IPO sample beyond 2004. We use the NBER bridge file to Compustat to match patents to IPO firms. This link allows us to consistently evaluate the innovation activity for IPO firms starting well before they go public.

The NBER patent database is subject to two types of truncation problems. We follow the innovation literature to correct for the truncation problems. First, patents are recorded in the database only after they are granted and the lag between patent applications and patent grants is significant (about two years on average). As we approach the last few years for which there are patent data available (e.g., 2005 and 2006 in the database used in this paper), we observe a smaller number of patent applications that are eventually granted. This is because many patent applications filed during these years were still under review and had not been granted until 2006. Following Hall, Jaffe, and Trajtenberg (2001, 2005), we correct for the truncation bias in patent counts using the "weight factors" computed from the application-grant empirical distribution. The second type of truncation problem is stemming from citation counts. Patents tend to receive citations over a long period of time, so the citation counts of more recent patents are significantly downward biased. Following Hall, Jaffe, and Trajtenberg (2001, 2005), the citation truncation is corrected by estimating the shape of the citation-lag distribution.

The NBER patent database is unlikely to be subject to survivorship bias. An eventually granted patent application is counted and attributed to the applying firm at the time when the patent application is submitted, even if the firm is later acquired or goes bankrupt. In addition, patent citations attribute to a patent, but not a firm. Hence, a patent assigned to an acquired or bankrupt firm can continue to receive citations for many years even after it goes out of existence. We construct two measures for a firm's annual innovation output.[17] The first measure, LNCOUNT, is the natural logarithm of annual truncation-adjusted patent count for a firm. Specifically, this variable counts the number of patent applications filed in that year that is eventually granted. However, a simple count of patents may not distinguish breakthrough innovations from incremental technological discoveries.[18] Therefore, we construct a second measure, LNCITE, which intends to capture the importance of patents by counting the number of citations received by each patent in the subsequent years. To better capture the impact of patents, we exclude self-citations when we compute citations per patent, but our results are robust to including self-citations. To avoid losing firm-year observations with zero patents or zero citations per patent, we add one to the actual values when taking natural logarithm.

[17] We construct the innovation variables based on the patent application year. As suggested by the innovation literature (e.g., Griliches, Pakes, and Hall (1987)), the application year is more important than the grant year since it is closer to the time of the actual innovation.

[18] Griliches, Pakes, and Hall (1987) show that the distribution of patents' value is extremely skewed, i.e., most of the value is concentrated in a small number of patents.

It is important to note that using patenting activity to measure corporate innovation is not without limitations. For example, different industries have various innovation propensity and duration. Young firms in some industries might abstain from patenting for competitive reasons. Therefore, fewer patents generated in an industry might not necessarily be reflective of a less innovative industry. However, we believe that an adequate control for heterogeneity across industries and firms should alleviate this concern and lead to reasonable inferences that can be applicable across industries and firms.

4.4. Measures of Firm Quality and Governance

In order to separate the effect of management quality from that of other aspects of firm quality and internal governance, we control for these other aspects by including the following variables as controls in our multivariate tests. The first proxy of firm quality we use is firm size, defined as the natural logarithm of the book of value of firm's assets immediately prior to IPO (LNSIZE). The second proxy of firm quality is firm age, defined as the natural logarithm of one plus the firm's age (LNAGE). The larger and older the firm, the greater its quality.[19] Further, we control for the proportion of outside directors (directors who are not executive officers, founders, former employees, or anyone who is engaged in business dealings with the firm) in the firm's board of directors (ODIR). Outside directors can enhance firm quality by, first, providing linkages to external parties such as underwriters, financial institutions, and auditors, and, second, by providing additional knowledge and expertise (inputs and perspectives) to the firm's management. The greater the proportion of outside directors, the greater the firm's quality.[20] We also control for insider stock ownership defined as the proportion of voting power held by firm insiders such as executive officers and directors after the IPO (INSIDERA). Next, we control for CEO/Chairman-of-the-board duality by creating a dummy variable equal to one if a firm's CEO is also its Chairman of the board of directors, and zero otherwise (BOSS). Separation of the roles of CEO and the Chairman of the board of directors creates greater management accountability and enhances internal governance and management

[19] These measures of firm quality have been widely used in the literature (Ritter (1984), Michaely and Shaw (1994)).
[20] Several studies in the corporate control literature demonstrated that outside directors enhance firm value (see, e.g., Cotter, Shivdasani, and Zenner (1997) and Borokhovich, Parrino, and Trapani (1996)).

quality.[21] Finally, we control for institutional investors' holdings immediately after the IPO (INSTP). The presence of institutional investors, as outside corporate governance monitors, can influence the innovation activity.

4.5. Summary Statistics

Table 2 summarizes our measures of innovation, individual management quality, and other control variables that we employ in the subsequent regressions and tests. In this study, we consider two widely-used measures of innovation, quantity (measured by the number of patents) and quality (measured by the citations per patent) both before and after the IPO. Pre-IPO innovation activity is measured as the sum of innovation activity (for both measures, quantity and quality) in years -2 and -1 before the IPO date; while post-IPO innovation activity (for both measures, quantity and quality) is measured as the sum of innovation activity in years 0 (IPO year), 1, and 2 after the IPO. In pre-IPO period, a firm in our sample has, on average, 0.81 granted patents (COUNTPRE) with each patent receiving 2.22 non-self-citations (CITEPRE). In post-IPO period, a firm has, on average, 5.48 granted patents (COUNTPOST) with each patent receiving 11.21 non-self-citations (CITEPOST). Since the distributions of patent counts and citations per patent are highly right skewed, we use the natural logarithm of patent counts and citations per patent in our analysis. To avoid losing firm-year observations with zero patent or citation, we add one to the actual value when calculating the natural logarithm.

Next, we turn to management quality variables used in this study. The mean (median) size of a firm's management team (TSIZE) is 6.78 (6), with the smallest management team consisting of one member and the largest of 19 members. On average, 15.6% of management team members have an MBA degree (PMBA), 6.6% have a CPA certification (PCPA), 55.4% have held a top management position at another firm prior to joining the IPO firm (PFTEAM), 2.4% have been partners in a law or accounting firm (PLAWACC), 59.2% are employed in core functional areas of their firms (PCORE). On average CEOs earn 29.3% more than the average member of their management team (FCEO). The

[21] Yermack (1997) shows that firms which separate the roles of a CEO and a Chairman of the board receive higher valuations. Rechner and Dalton (1991) show that such firms outperform those that combine these roles.

average tenure of management team members (TENURE) ranges from one to 30 years, with a mean (median) of 4.43 (3.29) years. Further, the mean (median) tenure heterogeneity (TENHET) of management teams is 0.689 (0.573). The average number of management team members who sit on other companies' boards is 0.53 (BOARDS). The mean (median) MQF score (MQF) of sample firms is 0 (-0.06), with a minimum value of -2.46 and a maximum value of 4.51.

Finally, we turn to our control variables. In the IPO literature, two often-used control variables are firm size and firm age. In our multivariate tests, we use the natural logarithms of the two variables. On average, 69.7% of the directors on IPO firms' boards are outsiders (ODIR). The mean (median) percentage of voting power owned by firm officers and directors immediately after the IPO (INSIDERA) is 42.7% (43.8%). CEOs act as board chairmen (BOSS) in 55.8% of the firms in our sample. On average, 21.4% of equity shares held by institutional investors (INSTP). The average R&D expenses, capital expenditures, and net income as a percentage of assets (RDASSETS, CAPEXASSETS, and ROA, respectively) for the firms in our sample in the year of IPO are 9.6%, 6.6%, and -3.3%, respectively.

5. Empirical Tests and Results

5.1. The Effect of Management Quality on Pre- and Post-IPO Innovation

5.1.1. OLS Analysis of the Relationship between Management Quality and Innovation

In this section we test hypothesis **H1** in a multivariate regression setting. This hypothesis predicts that firms with higher management quality will be more innovative (both before and after the IPO) as measured by the quantity as well as the quality of innovation. Our regression specification is as follows:

$$\text{Dependent variable}_i = \beta_0 + \beta_1 MQF_i + \beta_2 TENURE_i + \beta_3 TENHET_i + \beta_4 LNSIZE_i + \beta_5 LNAGE_i + \beta_6 ODIR_i + \beta_7 INSIDERA_i + \beta_8 BOSS_i + \beta_8 RDASSETS_i + \beta_9 CAPEXASSETS_i + \beta_{10} ROA_i + \beta_{11} INSTP_i + \varepsilon_i , \quad (1)$$

where dependent variable is either LNCOUNTPRE, LNCITEPRE, LNCOUNTPOST, or LNCITEPOST. We also include industry dummies (at 2-digit SIC level) to capture industry effects. For efficiency, we cluster the standard errors of our estimates by industry. We expect a positive coefficient on management quality factor (MQF). Table 3 reports the results of our estimation. Regressions 1 and 3 report the results for the quantity of innovation activity of the firms in our sample in pre- and post-IPO years, respectively, whereas regressions 2 and 4 report the results for the quality of innovation activity in pre- and post-IPO years, respectively. In regression 1, with pre-IPO quantity of innovation (LNCOUNTPRE) as the dependent variable, management quality factor score (MQF) has a positive and highly significant coefficient estimate, indicating that the effect of management quality on the quantity of patents in pre-IPO years is positive even after controlling for firm size, age, internal governance mechanisms, and industry effects. In regression 2, we repeat the same regression for the quality of innovation measured as the number of citations per patent in the pre-IPO years (LNCITEPRE), and find that the coefficient estimate of the management quality factor score (MQF) is positive and highly significant as well, implying that the effect of management quality on the quality of patents filed in pre-IPO years (and eventually granted) is significantly positive. Hence, these findings indicate that management quality has a positive effect on the pre-IPO innovation activity of entrepreneurial firms. Next, in regressions 3 and 4, with post-IPO innovation quantity (LNCOUNTPOST) and quality (LNCITEPOST) as the dependent variables, respectively, management quality factor score (MQF) has positive and highly significant coefficient estimates, indicating that the effect of management quality on the post-IPO innovation activity of entrepreneurial firms is significantly positive as well.

5.1.2. OLS Analysis of the Relationship between Individual Management Quality Proxies and Innovation

In this section, we test the effect of individual management quality variables on firms' innovation activity (both before and after the IPO) measured by the quantity as well as the quality of innovation. The results of this analysis are reported in Tables 4 (for pre-IPO innovation) and 5 (for post-IPO innovation). Panels A and B in both tables report the results for the quantity and quality of innovation, respectively. Panel A of Table 4 reports the results of our regressions of LNCOUNTPRE on various individual management quality variables along with a host of control variables as in the previous section and Panel B of Table 4 reports the results of similar regressions with LNCITEPRE as the dependent variable. We find that the percentage of management team members with MBA degrees (PMBA) and the percentage of management team members with core functional expertise (PCORE) have a significantly positive effect on the quality of pre-IPO innovation, whereas the management team size (TSIZE) has a significantly positive effect on both the quantity and quality of pre-IPO innovation. We also find that the average tenure of management team members (TENURE) and the percentage of management team members who were previously law or accounting partners (PLAWACC) have a significantly negative effect on both the quantity and quality of pre-IPO innovation.

In Table 5, we find that the percentage of management team members with MBA degrees (PMBA) has a significantly positive effect on the quantity of post-IPO innovation; the percentage of management team members with prior managerial experience (PFTEAM) and the percentage of management team members with core functional expertise (PCORE) have a significantly positive effect on the quality of post-IPO innovation; and the management team size (TSIZE) has a significantly positive effect on both the quantity and quality of post-IPO innovation. We also find that the average tenure of management team members (TENURE), the percentage of management team members who were previously law or accounting partners (PLAWACC), and the percentage of management team members who are CPAs (PCPA) have a significantly negative effect on both the quantity and quality of post-IPO innovation.

The negative impact of TENURE on innovation is perhaps due to the fact that many firms that are more innovative tend to be younger start-ups; therefore, their management team members might have spent less time with such firms. Further, managers who have been partners in law or accounting firms (PLAWACC) or managers who are CPAs (PCPA) may have a limited role to play in non-traditional younger start-ups that are more innovative. In sum, despite the fact that the effect of some individual management quality variables on innovation is more prominent than that of others, our findings in this and the previous section suggest that the overall effect of management quality on innovation (both before and after the IPO) is consistently positive (as measure by our management quality factor MQF), which provides support for our hypothesis **H1**.

5.1.3. Instrumental Variable Analysis of the Relationship between Management Quality and Innovation

While we show above that management quality has a significant effect on the innovativeness (both before and after the IPO, and as measured by the quantity as well as the quality of innovation) of the firms, it can be argued that management quality itself can be affected by firms that are more innovative. In other words, innovative firms are more likely to attract higher quality managers. If this is the case then our OLS analysis would suffer from a potential endogeneity problem, where management quality variable may be correlated with error terms making our OLS coefficient estimates biased.

A common solution used in the literature to deal with endogeneity problems is to employ the two-stage least squares (2SLS) methodology and make use of instrumental variables to generate exogenous variation in endogenous variables. However, instrumental variable estimation presents several challenges. First, finding good instruments is rather difficult since they should have a relatively high correlation with endogenous variables and be virtually uncorrelated with firm characteristics that we study. In other words, instruments should not suffer from the same endogeneity problem as our endogenous variables. Second, 2SLS can be less efficient than OLS when it generates relatively large standard errors (Wooldridge, 2010, page 111).

The instrument for management quality that we use is the percentage of the population with a bachelor's degree or higher in the same area (designated by the three-digit zip code) where the IPO firm's headquarters is located (EDUC). Assuming that firms, especially new start-ups, are more likely to hire managers who live in close geographical proximity (such as the same city or larger urban area) rather than invite them from more distant areas (such as other states or more distant areas within the same state), then we would expect the managers of firms located in areas with a higher percentage of the population with a bachelor's degree or higher to be more educated. Since one way that we measure management quality is by measuring the education level of managers, we expect the management quality of firms located in areas with a larger educated population to be higher. At the same time we do not expect a significant relationship between the percentage of the population in a given area with a bachelor's degree or higher and the characteristics of firms located in that area, which makes EDUC a good instrument for management quality.

We obtain the data on educational attainment of U.S. population by congressional districts from Census Bureau for years 1990 and 2000. Since educational attainment steadily increases over time (confirmed by higher numbers for 2000 compared to 1990) we use linear interpolation to fill in the missing numbers for years 1993 through 2004. Then we match these congressional district data with U.S. zip codes and calculate average educational attainment for three-digit zip code areas.[22]

The results of our instrumental variable analysis are presented in Table 6. Regressions 1 (pre-IPO) and 4 (post-IPO) present first stage regressions of the management quality factor score (MQF) on our instrument (EDUC) and other control variables. The coefficient estimates of EDUC in both regressions are positive and highly significant indicating a strong positive correlation between EDUC and MQF. These regressions also report the F-statistic of the weak instruments test (or the test of excluded instruments). This test is used to determine whether instrumental variables used in first stage regressions are strong. In their survey of the literature on weak instruments, Stock, Wright, and Yogo (2002) develop benchmarks for the necessary magnitude of the F-statistic. They indicate that if the number of instruments is equal to one, then the critical value of the F-statistic is 8.96. Since the F-statistics reported for regressions 1 and 4 are well above the critical value (18.79 and 17.45, respectively), the null hypothesis that our instrument is weak is strongly rejected for our 2SLS estimation. The second stage regressions for the pre-IPO innovation variables (LNCOUNTPRE in regression 2 and LNCITEPRE in regression 3) show a significantly positive relationship between management quality and pre-IPO innovation both in terms of the quantity and quality of innovation. The second stage regressions for the post-IPO innovation variables (LNCOUNTPOST in regression 2 and LNCITEPOST in regression 3) show a significantly positive relationship between management quality and the quantity of post-IPO innovation. These results, consistent with our findings in the previous sections, indicate that, even after controlling for the potential

[22] We decided to use three-digit zip code areas for the construction of our instrument, since, on average, areas covered by three-digit zip codes can be comfortably crossed within reasonable amount of time for an employee to commute to work. Two-digit zip code areas are too large whereas four-digit zip code areas are too restrictive.

endogeneity of management quality, it still has a significantly positive effect on the innovation activity of entrepreneurial firms both before and after their IPOs. This provides further support for our hypothesis **H1**.

5.2. Relationship between Pre-IPO Innovation, Management Quality, and Anti-Takeover Provisions

5.2.1. Relationship between Pre-IPO Innovation and Anti-Takeover Provisions

In this section, we test our long-term value creation (**H2A**) and management entrenchment (**H2B**), hypotheses which predict that firms which are more innovative (as measured by their pre-IPO innovation activity) will have either more (**H2A**) or less (**H2B**) ATPs in their corporate charters at IPO. To test these hypotheses, we regress (using Poisson maximum-likelihood estimation technique) the total number of firm-level ATPs in a firm's corporate charter at IPO (see Appendix A of Chemmanur, Paeglis, and Simonyan (2011) for a detailed description of these 19 firm-level ATPs) on pre-IPO innovation and control variables. Regressions 1 and 2 in Table 7 report the results of these regressions. We find that both LNCOUNTPRE and LNCITEPRE have a significantly positive effect on the number of ATPs. This indicates that both the quantity and the quality of pre-IPO innovation activity of an entrepreneurial firm are positively correlated with the number of ATPs in its corporate charter at the time of IPO. This provides support for our long-term value creation hypothesis **H2A** and contradicts the management entrenchment hypothesis **H2B**.

5.2.2. Relationship between Pre-IPO Innovation, Management Quality, and Anti-Takeover Provisions

In this section, we investigate the joint effect of pre-IPO innovation and management quality on the number of ATPs at IPO and test hypotheses **H3A** and **H3B**. We regress (using Poisson maximum-likelihood estimation technique) the total number of firm-level ATPs in a firm's corporate charter at IPO on a dummy variable Q1 and other control variables. Dummy variable Q1 takes a value of one for firms with above median MQF score and above median LNCOUNTPRE.[23] In other words, Q1 takes a value of

[23] We get similar results if we use LNCITEPRE instead of LNCOUNTPRE to construct the dummy variable Q1.

one for firms with high management quality and high pre-IPO innovation (measured by the quantity of pre-IPO innovation), and a value of zero for the remaining firms in our sample. We expect a positive (negative) coefficient for Q1 if the joint effect of pre-IPO innovation and management quality on the number of ATPs is positive (negative). Regression 3 in Table 7 presents the results of our estimation. Dummy variable Q1 has a significantly positive coefficient estimate at the 5% level indicating that the joint effect of pre-IPO innovation and management quality is significantly positive on the number of ATPs in a firm's corporate charter at IPO. Thus, the firms which have greater pre-IPO innovation activity combined with higher management quality tend to have the greatest number of ATPs when they go public compared to the other firms in our sample. This finding provides support for our long-term value creation hypothesis **H3A** and contradicts the management entrenchment hypothesis **H3B**.

Next, to determine how pre-IPO innovation and management quality directly affect the number of ATPs as well as how they interact in this effect, we regress (using Poisson maximum-likelihood estimation technique) the total number of firm-level ATPs in a firm's corporate charter at IPO on pre-IPO innovation variables, management quality dummy, the interaction of pre-IPO innovation variables with management quality dummy, and control variables. First, to be able to draw meaningful conclusion from this interaction analysis, we use a dummy variable for management quality instead of the continuous variable MQF. We use a dummy variable which takes a value of one for the firms with above median MQF score, and zero otherwise (MQFDUMMY). Second, given that pre-IPO innovation variables and management quality are highly correlated, using both as independent variables in a regression may potentially create multicollinearity problems. To tackle this issue we regress LNCOUNTPRE and LNCITEPRE on MQFDUMMY, TENURE, and TENHET, and take the residuals of such regressions (in other words, the variation in innovation measures not explained by management quality) to be our pre-IPO innovation activity proxies for quantity (LNRESCOUNT) and quality (LNRESCITE) of innovation.

Our regression specification using the quantity of innovation proxy is as follows.

$$\begin{aligned}\mathrm{ATP_i} &= \beta_0 + \beta_1 LNRESCOUNT_i + \beta_2 LNRESCOUNT_i \times MQFDUMMY_i + \beta_3 MQFDUMMY_i \\ &+ \beta_4 TENURE_i + \beta_5 TENHET_i + \beta_6 LNSIZE_i + \beta_7 LNAGE_i + \beta_8 ODIR_i + \beta_9 INSIDERA_i \\ &+ \beta_{10} BOSS_i + \beta_{11} RDASSETS_i + \beta_{12} CAPEXASSETS_i + \beta_{13} ROA_i + \beta_{14} INSTP_i + \varepsilon_i .\end{aligned} \tag{2}$$

We also run a regression where we replace LNCOUNTRES with LNCITERES. Regressions 4 and 5 in Table 7 present the results of these regressions. We find that the coefficient estimates of LNRESCOUNT and LNRESCITE are significantly positive, indicating that pre-IPO innovation has a significantly positive effect on the number of ATPs in low management quality firms. Further, the interaction terms of pre-IPO innovation proxies with the management quality dummy have significantly negative coefficient estimates, but smaller in absolute terms than the coefficient estimates of the pre-IPO innovation proxies.[24] This implies that, while pre-IPO innovation positively affects the number of ATPs in high quality management firms as well, the effect of pre-IPO innovation on the number of ATPs is less pronounced in high quality management firms compared to low quality management firms. In other words, pre-IPO innovation and management quality act as substitutes in their effect on the number of ATPs. Finally, the direct effect of management quality as measured by MQFDUMMY on the number of ATPs is significantly positive as well.

5.3. Relationship between Pre-IPO Innovation, Management Quality, and the IPO Market

In this section, we test the hypotheses regarding the effect of pre-IPO innovation and management quality on two important variables related to the IPO market: IPO firm valuation and firm age at IPO.

5.3.1. Relationship between Pre-IPO Innovation and IPO Firm Valuation

We first test our hypothesis **H4,** which predicts that firms which are more innovative pre-IPO will receive higher valuations at IPO. We measure IPO firm valuation using Tobin's Q, which is the ratio of the market value of assets over the book value of assets, where the market value of assets is equal to the book value of assets minus the book value of equity plus the product of the number of shares outstanding and share price. We measure firm valuation in the IPO market by using the IPO offer price as the share price in the above definition (QOP) and we measure IPO firm valuation in the immediate secondary market by using the first trading day closing price as the share price in the above definition (QFTD). The

[24] The test of the linear restriction, that the sum of the effects of pre-IPO innovation and the interaction term is zero, is strongly rejected with *p*-value less than 1% significance level.

book value of assets and the book value of equity for IPO firms are taken from the first available post-IPO quarter on Compustat. To construct QOP and QFTD we use the number of IPO firm outstanding shares and the first trading day IPO firm closing price from CRSP (IPO offer price is taken from the SDC/Global New Issues Database).

To test our hypothesis **H4**, we run quantile/median regressions of firm valuation measures on pre-IPO innovation proxies and other control variables.[25] The results of these regressions are presented in Panel A of Table 8. Regressions 1 and 2 use LNCOUNTPRE as a proxy of pre-IPO innovation and regressions 3 and 4 use LNCITEPRE as a proxy of pre-IPO innovation. We find that both pre-IPO innovation proxies have a significantly positive effect on IPO firm valuations both in the IPO market (QOP) as well as in the immediate secondary market (QFTD). Thus, our findings indicate that firms which are more innovative before IPO receive higher valuations in both IPO and immediate secondary markets, providing support for our hypothesis **H4**.

5.3.2. Relationship between Pre-IPO Innovation, Management Quality, and IPO Firm Valuation

Next, we investigate the joint effect of pre-IPO innovation and management quality on IPO firm valuation. Similar to our analysis of the joint effect of pre-IPO innovation and management quality on the number of ATPs in section 5.2.2, we regress (using quantile/median regressions) IPO firm valuation proxies on a dummy variable Q1 and other control variables. Dummy variable Q1 takes a value of one for firms with above median MQF score and above median LNCOUNTPRE. In other words, Q1 takes a value of one for firms with high management quality and high pre-IPO innovation (measured by the quantity of pre-IPO innovation), and a value of zero for the remaining firms in our sample. We expect a positive (negative) coefficient for Q1 if the joint effect of pre-IPO innovation and management quality on IPO firm valuation is positive (negative). Regressions 1 and 2 in Panel B of Table 8 present the results of our estimation. Dummy variable Q1 has significantly positive coefficient estimates at the 1% level indicating

[25] We choose to use quantile (median) regressions instead of regular OLS regressions given the large outliers in firm valuation measures. Quantile (median) regressions estimate the conditional median of dependent variables given certain values of independent variables instead of the conditional mean estimated by OLS and therefore are more appropriate in this context.

that the joint effect of pre-IPO innovation and management quality is significantly positive on IPO firm valuation both in the IPO (QOP) as well as in the immediate secondary market (QFTD). Thus, the firms which have greater pre-IPO innovation activity combined with higher management quality tend to receive the highest valuations in the IPO and immediate secondary market compared to the other firms in our sample. This finding provides support for our hypothesis **H5**.

Next, to determine how pre-IPO innovation and management quality directly affect IPO firm valuation as well as how they interact in this effect, we regress (using quantile/median regressions) IPO firm valuation proxies on pre-IPO innovation variables (measuring either quantity or quality of pre-IPO innovation), management quality dummy, the interaction of pre-IPO innovation variables with management quality dummy, and control variables. In other words, we run quantile/median regressions similar to specification (2) in section 5.2.2 by using QOP and QFTD as dependent variables. Regressions 3 through 6 in Panel B of Table 8 present the results of our estimation. We find a significantly positive coefficient estimate for LNRESCOUNT in QOP regression. This indicates that the quantity of pre-IPO innovation has a significantly positive effect on low management quality firm valuation in the IPO market. The coefficient estimate of the interaction term of LNRESCOUNT with MQFDUMMY is negative but not statistically significant implying that the effect of the quantity of pre-IPO innovation on high management quality firm valuation in the IPO market is somewhat similar to that in low management quality firms (i.e., significantly positive). Further, while we do not find a significant coefficient estimate for LNRESCITE in QFTD regression (implying that the quality of pre-IPO innovation does not have a significant effect on secondary market valuation of low management quality firms), the interaction term of LNRESCITE with MQFDUMMY in that regression is positive and significant at the 5% level, indicating that the quality of pre-IPO innovation has a significantly positive effect on secondary market valuation of firms with high management quality. Finally, the direct effect of management quality as measured by MQFDUMMY on both IPO and secondary market valuation is significantly positive. In sum, these findings provide an indication that management quality, in addition to its direct positive effect on IPO valuation, plays an important role in enhancing the positive effect of pre-IPO innovation on IPO firm valuation.

5.3.3. Relationship between Pre-IPO Innovation and Firm Age at IPO

We first test our hypothesis **H6,** which predicts that firms that are more innovative (as measured by pre-IPO innovation activity) will go public at a younger age. We run OLS regression of firm age at IPO measured in years (AGE) on pre-IPO innovation and control variables. Regressions 1 and 2 in Table 9 report the results of these regressions. We find that both LNCOUNTPRE and LNCITEPRE have a significantly negative effect on firm age at IPO. This indicates that the greater quantity and quality of pre-IPO innovation activity of an entrepreneurial firm allows it to go public at a younger age. This finding provides support for hypothesis **H6**.

5.3.4. Relationship between Pre-IPO Innovation, Management Quality, and Firm Age at IPO

Next, we investigate the joint effect of pre-IPO innovation and management quality on firm age at IPO. Similar to our analysis of the joint effect of pre-IPO innovation and management quality on the number of ATPs and valuation in sections 5.2.2 and 5.3.2, respectively, we regress (using OLS regressions) firm age at IPO on a dummy variable Q1 and other control variables. Dummy variable Q1 takes a value of one for firms with above median MQF score and above median LNCOUNTPRE. In other words, Q1 takes a value of one for firms with high management quality and high pre-IPO innovation (measured by the quantity of pre-IPO innovation), and a value of zero for the remaining firms in our sample. We expect a negative (positive) coefficient for Q1 if the joint effect of pre-IPO innovation and management quality on firm age at IPO is negative (positive). Regression 3 in Table 9 presents the results of our estimation. Dummy variable Q1 has significantly negative coefficient estimate at the 5% level indicating that the joint effect of pre-IPO innovation and management quality is significantly negative on firm age at IPO. Thus, the firms which have greater pre-IPO innovation activity combined with higher management quality tend to go public at a younger age compared to the other firms in our sample. This finding provides support for our hypothesis **H7**.

Next, to determine how pre-IPO innovation and management quality directly affect firm age at IPO as well as how they interact in this effect, we regress (using OLS regressions) firm age at IPO on pre-IPO innovation variables (measuring either quantity or quality of pre-IPO innovation), management quality dummy, the interaction of pre-IPO innovation variables with management quality dummy, and control variables. In other words, we run OLS regressions similar to specification (2) in section 5.2.2 by using AGE as a dependent variable. Regressions 4 and 5 in Table 9 present the results of our estimation. We do not find significant coefficient estimates either for pre-IPO innovation proxies, interaction terms, or management quality dummy. Thus, these results indicate that while the direct effects of pre-IPO innovation and management quality on firm age at IPO are insignificant, their joint effect is significantly negative.

5.4. Relationship between Pre-IPO Innovation, Management Quality, and Post-IPO Operating Performance

5.4.1. Relationship between Pre-IPO Innovation and Post-IPO Operating Performance

In this section, we first test our hypothesis **H8**, which predicts that greater pre-IPO innovation translates into better post-IPO operating performance of firms going public. We use the changes in post-IPO operating income before depreciation plus interest income scaled by total asserts (OIBDA) as our measure for operating performance. We calculate the changes in OIBDA for years 0, 1, 2, and 3 after the IPO (where year zero is the year of IPO) relative to the year before the IPO (year -1); in other words ΔOIBDA is the difference between OIBDA in a given post-IPO year (0, 1, 2, or 3) and OIBDA in year -1.

To test our hypothesis **H8**, we run quantile/median regressions of the changes in post-IPO operating performance on pre-IPO innovation proxies and other control variables.[26] The results of these regressions are presented in Table 10. Regressions 1 through 4 use LNCOUNTPRE as a proxy of pre-IPO

[26] We employ quantile regressions for this analysis given large outliers in operating performance measures.

innovation and regressions 5 through 8 use LNCITEPRE as a proxy of pre-IPO innovation. We find that both pre-IPO innovation proxies have a significantly positive effect on the changes in post-IPO operating performance (except for the effect of LNCOUNTPRE on ΔOIBDA from year -1 to year 3). Thus, our findings indicate that firms which are more innovative before IPO realize greater improvements in their post-IPO operating performance, providing support for our hypothesis **H8**.

5.4.2. Relationship between Pre-IPO Innovation, Management Quality, and Post-IPO Operating Performance

Finally, we investigate the joint effect of pre-IPO innovation and management quality on the changes in post-IPO operating performance. Similar to our analysis of the joint effect of pre-IPO innovation and management quality on the number of ATPs, firm valuation, and firm age at IPO in sections 5.2.2, 5.3.2, and 5.3.4, respectively, we regress (using quantile/median regressions) the changes in post-IPO operating performance measures on a dummy variable Q1 and other control variables. Dummy variable Q1 takes a value of one for firms with above median MQF score and above median LNCOUNTPRE. In other words, Q1 takes a value of one for firms with high management quality and high pre-IPO innovation (measured by the quantity of pre-IPO innovation), and a value of zero for the remaining firms in our sample. We expect a positive (negative) coefficient for Q1 if the joint effect of pre-IPO innovation and management quality on the changes in post-IPO operating performance is positive (negative). Regressions 1 through 4 in Table 11 present the results of our estimation. Dummy variable Q1 has significantly positive coefficient estimates in all four regressions indicating that the joint effect of pre-IPO innovation and management quality is significantly positive on the changes in post-IPO operating performance. Thus, the firms which have greater pre-IPO innovation activity combined with higher management quality tend to realize the largest improvements in their post-IPO performance compared to the other firms in our sample. These findings provide support for our hypothesis **H9**.

Next, to determine how pre-IPO innovation and management quality directly affect the changes in post-IPO operating performance as well as how they interact in this effect, we regress (using quantile/median regressions) the changes in post-IPO operating performance measures on the quantity of pre-IPO innovation, management quality dummy, the interaction of the quantity of pre-IPO innovation with management quality dummy, and control variables.[27] In other words, we run quantile/median regressions similar to specification (2) in section 5.2.2 by using the changes in post-IPO operating performance measures (ΔOIBDA from year -1 to years 0, 1, 2, and 3) as dependent variables. Regressions 5 through 8 in Table 11 present the results of our estimation. While we do not find a significant coefficient estimate for LNRESCOUNT in these regressions (implying that the quantity of pre-IPO innovation does not have a significant effect on the changes in post-IPO operating performance of low management quality firms), the interaction term of LNRESCOUNT with MQFDUMMY is positive and significant in ΔOIBDA -1 to 1 regression at the 5% level, indicating that the quantity of pre-IPO innovation has a significantly positive effect on the changes in post-IPO operating performance (from year -1 before IPO to year 1 after IPO) of firms with high management quality. However, we do not find similar significance for the other post-IPO years that we study. Finally, the direct effect of management quality as measured by MQFDUMMY on the changes in post-IPO operating performance is significantly positive. In sum, these findings provide an indication that management quality, in addition to its direct positive effect on IPO valuation, plays somewhat an important role in enhancing the positive effect of pre-IPO innovation on the changes in post-IPO operating performance as well.

6. Conclusion

We make use of hand-collected data on the quality and reputation of the management teams of a large sample of venture-backed entrepreneurial firms undertaking initial public offerings (IPOs) to address two research questions: How does the human capital of a firm's top management team ("management quality") affect the quantity and quality of innovation undertaken by it? Second, what are the effects of the pre-IPO innovativeness of a firm and its management quality on the characteristics of its IPO and its post-

[27] To conserve space, we report the results only for the quantity of pre-IPO innovation activity, but in unreported results, we find similar results for the quality of pre-IPO innovation activity.

IPO operating performance? We hypothesize that higher quality management teams hire better scientists and other researchers; invest in more innovative projects; and manage these projects more ably, leading to higher innovation productivity. Consistent with this, we show in the first part of our analysis using ordinary least squares and instrumental variable analyses that firms with higher management quality exhibit higher innovation productivity in the years immediately before and after their IPOs. The above results hold for both the quantity (number of patents) and quality (citations per patent) of innovation. In the second part of our analysis, we find that firms with greater pre-IPO innovativeness are associated with a larger number of anti-takeover provisions in their corporate charter (determined at IPO), higher IPO valuations, younger age at IPO, and better post-IPO operating performance. Further, we find that the above effects are enhanced if innovative firms are managed by teams of higher management quality.

References

Aghion, P., Tirole, J., 1994. On the Management of Innovation. *Quarterly Journal of Economics* 109, 1185–1209.

Aghion, P., Van Reenen, J., Zingales, L., 2013. Innovation and Institutional Ownership. *American Economic Review* 103, 277–304.

Atanassov, J., 2013. Do Hostile Takeovers Stifle Innovation? Evidence from Antitakeover Legislation and Corporate Patenting. *Journal of Finance* 68, 1097–1131.

Azoulay, P., Graff Zivin, J.S., Manso, G., 2011. Incentives and Creativity: Evidence from the Academic Life Sciences. *RAND Journal of Economics* 42, 527–554.

Bandiera, O., Barankay, I., Rasul, I., 2005. Social Preferences and the Response to Incentives: Evidence from Personnel Data. *Quarterly Journal of Economics* 120 (3), 917–962.

Bandiera, O., Barankay, I., Rasul, I., 2010. Social Incentives in the Workplace. *Review of Economic Studies* 77 (2), 417–458.

Barker, V.L., Mueller, G.C., 2002. CEO Characteristics and Firm R&D Spending. *Management Science* 48 (6), 782–801.

Becker, G.S., 1962. Investment in Human Capital: A Theoretical Analysis. *Journal of Political Economy* 70 (5), 9–49.

Bertrand, M., Schoar, A., 2003. Managing with Style: The Effect of Managers on Firm Policies. *Quarterly Journal of Economics* 118 (4), 1169–1208.

Borokhovich, K., Parrino, R., Trapani, T., 1996. Outside Directors and CEO Selection. *Journal of Financial and Quantitative Analysis* 31 (3), 337–355.

Cary, W., 1969. Corporate Devices Used to Insulate Management from Attack. *Antitrust Law Journal* 39, 318–333.

Clementi, G., 2002. IPOs and the Growth of Firms. New York University Working Paper.

Chemmanur, T., 1993. The Pricing of Initial Public Offerings: A Dynamic Model with Information Production. *Journal of Finance* 48 (1), 285–304.

Chemmanur, T., Fulghieri, P., 1999. A Theory of the Going-Public Decision. *Review of Financial Studies* 12, 249–279.

Chemmanur, T., Jiao, Y., 2012. Dual-Class IPOs: A Theoretical Analysis. *Journal of Banking and Finance* 36, 305–319.

Chemmanur, T., Loutskina, E., Tian, X., 2014. Corporate Venture Capital, Value Creation, and Innovation. *Review of Financial Studies* 27 (8), 2434–2473.

Chemmanur, T., Paeglis, I., 2005. Management Quality, Certification, and Initial Public Offerings. *Journal of Financial Economics* 76 (2), 331–368.

Chemmanur, T., Paeglis, I., Simonyan, K., 2011. Management Quality and Antitakeover Provisions. *Journal of Law and Economics* 54, 651–692.

Chemmanur, T., Simonyan, K., Tehranian, H., 2013. The Role of Management Quality in the IPOs of Venture-Backed Entrepreneurial Firms. Boston College Working Paper.

Chemmanur, T., Tian, X., 2013. Anti-Takeover Provisions, Innovation, and Firm Value: A Regression Discontinuity Analysis. Boston College Working Paper.

Cotter, J., Shivdasani, A., Zenner, M., 1997. Do Independent Directors Enhance Target Shareholder Wealth During Tender Offers? *Journal of Financial Economics* 43 (2), 195–218.

D'Aveni, R., 1990. Top Managerial Prestige and Organizational Bankruptcy. *Organization Science* 1 (2), 121–142.

Ederer, F., Manso, G., 2013. Is Pay-for-Performance Detrimental to Innovation? *Management Science* 59, 1498–1513.

Ferreira. D., Manso, G., Silva, A., 2014. Incentives to Innovate and the Decision to Go Public or Private. *Review of Financial Studies* 27, 256–300.

Field, L., Karpoff, J., 2002. Takeover Defenses of IPO Firms. *Journal of Finance* 57 (5), 1857–1889.

Fulghieri, P., Sevilir, M., 2009. Organization and Financing of Innovation, and the Choice between Corporate and Independent Venture Capital. *Journal of Financial and Quantitative Analysis* 44, 1291–1321.

Gaver, J., Gaver, K., 1993. Additional Evidence on the Association Between the Investment Opportunity Set and Corporate Financing, Dividend, and Compensation Policies. *Journal of Accounting and Economics* 16 (1–3), 125–160.

Griliches, Z., Pakes, A., Hall. B.H., 1987. The Value of Patents as Indicators of Inventive Activity. In *Economic Policy and Technological Performance*, eds. Dasgupta, P., Stoneman, P., (Cambridge University Press, Cambridge, UK).

Guay, W., 1999. The Sensitivity of CEO Wealth to Equity Risk: An Analysis of the Magnitude and Determinants. *Journal of Financial Economics* 53 (1), 43–71.

Grossman, S.J., Hart, O.D., 1988. One Share-One Vote and the Market for Corporate Control. *Journal of Financial Economics* 20, 175–202.

Hall, B., Jaffe, A., Trajtenberg, M., 2001. The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools. NBER Working Paper No. 8498.

Hall, B., Jaffe, A., Trajtenberg, M., 2005. Market Value and Patent Citations. *RAND Journal of Economics* 36, 16–38.

Hambrick, D., D'Aveni, R., 1992. Top Team Deterioration as Part of the Downward Spiral of Large Corporate Bankruptcies. *Management Science* 38 (10), 1445–1466.

Harman, H., 1976. *Modern Factor Analysis*, 3rd ed. (University of Chicago Press, Chicago, IL).

Harris, M., Raviv, A., 1988. Corporate Governance: Voting Rights and Majority Rules. *Journal of Financial Economics* 20, 203–235.

Harris, M., Raviv, A., 1989. The Design of Securities. *Journal of Financial Economics* 24 (2), 255–287.

Hirshleifer, D, Low, A., Teoh, S.H., 2012. Are Overconfident CEOs Better Innovators? *Journal of Finance* 67, 1457–1498.

Holmstrom, B., 1989. Agency Costs and Innovation. *Journal of Economic Behavior and Organization* 12, 305–327.

Johnson, W., Karpoff, J., Yi, S., 2013. The Bonding Hypothesis of Takeover Defenses: Evidence from IPO Firms. University of Washington Working Paper.

Kortum, S., Lerner, J., 2000. Assessing Contribution of Venture Capital to Innovation. *RAND Journal of Economics* 31, 674–692.

Lerner, J., Sorensen, M., Stromberg, P., 2011. Private Equity and Long-Run Investment: The Case of Innovation. *Journal of Finance* 66, 445–477.

Manso, G., 2011. Motivating Innovation. *Journal of Finance* 66, 1823–1860.

Michaely, R., Shaw, W., 1994. The Pricing of Initial Public Offerings: Tests of Adverse Selection and Signaling Theories. *Review of Financial Studies* 7 (2), 279–319.

Nanda, R., Rhodes-Kropf, M., 2013. Investment Cycles and Startup Innovation. *Journal of Financial Economics* 110, 403–418.

Porter, M., 1992. Capital Disadvantage: America's Failing Capital Investment System. *Harvard Business Review* 70, 65–82.

Rechner, P., Dalton, D., 1991. CEO Duality and Organizational Performance: A Longitudinal Analysis. *Strategic Management Journal* 12, 155–160.

Ritter, J., 1984. The Hot Issue Market of 1980. *Journal of Business* 57 (2), 215–240.

Ritter, J., Welch, I., 2002. A Review of IPO Activity, Pricing, and Allocations. *Journal of Finance* 57 (4), 1795–1828.

Seru, A., 2014. Firm Boundaries Matter: Evidence from Conglomerates and R&D Activity. *Journal of Financial Economics* 111, 381–405.

Spiegel, M., Tookes, H., 2014. An IPO's Impact on Rival Firms. Yale University Working Paper.

Stein, J., 1988. Takeover Threats and Managerial Myopia. *Journal of Political Economy* 96 (1), 61–80.

Stock, J.H., Wright, J.H., Yogo, M., 2002. A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments. *Journal of Business and Economic Statistics* 20 (4), 518–529.

Tian, X., Wang, T., 2014. Tolerance for Failure and Corporate Innovation. *Review of Financial Studies* 27 (1), 211–255.

Wooldridge, J.M., 2010. Econometric Analysis of Cross Section and Panel Data, 2nd ed. (The MIT Press, Cambridge, MA).

Williamson O.E., 1975. Markets and Hierarchies: Analysis and Antitrust Implications. (Free Press, New York, NY).

Yermack, D., 1997. Good Timing: CEO Stock Option Awards and Company News Announcements. *Journal of Finance* 52 (2), 449–476.

Table 1. Selected statistics related to a common factor analysis of eight measures of management quality and reputation

The sample consists of 1,851 venture-backed IPOs conducted between 1993 and 2004. MQF is the management quality factor score obtained using common factor analysis on the firm-size-, firm-age-, and industry-dummies-adjusted TSIZE, MBA, FTEAM, LAWACC, CPA, CORE, FCEO, and BOARDS. TSIZE is the size of a firm's management team, defined as the number of executive officers with a rank of vice president or higher. MBA is the number of management team members with MBA degrees. FTEAM is the number of management team members who have served as executive officers and/or vice presidents prior to joining the IPO firm. CORE is the number of management team members who have core functional expertise, namely, holding positions in operations and production, sales and marketing, research and development, and finance. LAWACC is the number of management team members who have previously been partners in law or accounting firms. CPA is the number of management team members who are Certified Public Accountants. FCEO is the ratio of CEO salary and bonus to the average salary and bonus of other management team members in the fiscal year preceding the IPO. BOARDS is the number of other companies' boards that management team members sit on.

Panel A. Estimated communalities of eight management quality measures.

Common factor	TSIZE	MBA	FTEAM	CORE	LAWACC	CPA	FCEO	BOARDS	Total
MQF	0.5694	0.1142	0.3414	0.4534	0.0315	0.0234	0.0055	0.0081	1.5469

Panel B. Eigenvalues of the reduced correlation matrices.

Common factor	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
MQF	1.71781	0.15770	0.08523	0.03864	-0.04332	-0.07560	-0.10934	-0.22429

Panel C. Correlations between the common factors and eight management quality measures.

Common factor	TSIZE	MBA	FTEAM	CORE	LAWACC	CPA	FCEO	BOARDS
MQF	0.9413	0.4161	0.7107	0.8130	0.0474	0.0937	0.0096	0.0402

Panel D. Descriptive statistics of the common factors extracted from eight management quality measures.

Common factor	Maximum	Third quartile	Median	First quartile	Minimum	Mean
MQF	4.5107	0.5204	-0.0557	-0.6239	-2.4631	0.0000

Table 2. Summary statistics

COUNTPRE is the number of patents a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. CITEPRE is the number of non-self-citations per patent a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. COUNTPOST is the number of patents a firm files for and is eventually granted in post-IPO years 0, 1, and 2 combined. CITEPOST is the number of non-self-citations per patent a firm files for and is eventually granted in post-IPO years 0, 1, and 2 combined. TSIZE is the size of a firm's management team, defined as the number of executive officers with a rank of vice president or higher. PMBA is the percentage of a firm's management team with MBA degrees. PCPA is the percentage of a firm's management team who are Certified Public Accountants. PFTEAM is the percentage of a firm's management team who have served as executive officers and/or vice presidents prior to joining the IPO firm. PCORE is the percentage of a firm's management team who have core functional expertise, namely, holding positions in operations and production, sales and marketing, R&D, and finance. PLAWACC is the percentage of a firm's management team who have previously been partners in law or accounting firms. FCEO is the ratio of CEO salary and bonus to the average salary and bonus of other management team members in the fiscal year preceding the IPO. BOARDS is the number of other companies' boards that management team members sit on. TENURE is the average number of years a firm's management team members have been with the firm. TENHET is the coefficient of variation of the management team members' tenures. MQF is the management quality factor score obtained using common factor analysis on the firm-size-, firm-age-, and industry-dummies-adjusted TSIZE, MBA, FTEAM, LAWACC, CPA, CORE, FCEO, and BOARDS. LNSIZE is the natural logarithm of the book value of the firm's assets immediately before the IPO. LNAGE is the firm age defined as the natural logarithm of one plus the firm age. ODIR is the percentage of outside directors in the board of directors. INSIDERA is the proportion of voting power owned by firm officers and directors immediately after the IPO. BOSS is an indicator variable equal to one if a CEO is also a Chairman of the board of directors, and zero otherwise. INSTP is the percentage of institutional stock holdings immediately after the IPO. CAPEXASSETS is capital expenditure scaled by firm assets in year 0. RDASSETS is R&D expenses scaled by firm assets in year 0. ROA is net income scaled by firm assets in year 0.

Variables	N	Min	Mean	Median	Max	SD
COUNTPRE	1,764	0	0.805	0	125.657	4.495
CITEPRE	1,764	0	2.218	0	241.445	10.845
COUNTPOST	1,731	0	5.475	0	658.302	23.160
CITEPOST	1,731	0	11.211	0	418.796	29.253
TSIZE	1,851	1	6.782	6	19	2.515
PMBA	1,851	0	0.156	0.111	1	0.187
PCPA	1,851	0	0.066	0	1	0.106
PFTEAM	1,851	0	0.554	0.571	1	0.263
PCORE	1,851	0	0.592	0.6	1	0.202
PLAWACC	1,851	0	0.024	0	1	0.075
FCEO	1,851	0	1.293	1.263	4.521	0.461
BOARDS	1,851	0	0.527	0	10	1.069
TENURE	1,851	1	4.431	3.286	30	3.512
TENHET	1,851	0	0.689	0.573	16.408	0.868
MQF	1,851	-2.463	0	-0.056	4.511	0.908
LNSIZE	1,851	12.683	17.242	17.024	22.969	1.447
LNAGE	1,851	0	2.044	1.946	5.063	0.779
ODIR	1,851	0	0.697	0.714	1	0.179
INSIDERA	1,851	0	0.427	0.438	1	0.206
BOSS	1,851	0	0.558	1	1	0.497
INSTP	1,851	0	0.214	0.183	1	0.157
RDASSETS	1,829	0	0.096	0.065	1.985	0.134
CAPEXASSETS	1,806	-0.003	0.066	0.040	0.802	0.081
ROA	1,825	-3.295	-0.125	-0.033	0.367	0.300

Table 3. Relation between innovation and management quality

The sample consists of 1,851 venture-backed IPOs conducted between 1993 and 2004. This table presents multivariate OLS regressions of pre- and post-IPO innovation variables on management quality variables and other control variables. LNCOUNTPRE, LNCITEPRE, LNCOUNTPOST, and LNCITEPOST are the natural logarithms of one plus COUNTPRE, CITEPRE, COUNTPOST, and CITEPOST, respectively. COUNTPRE is the number of patents a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. CITEPRE is the number of non-self-citations per patent a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. COUNTPOST is the number of patents a firm files for and is eventually granted in post-IPO years 0, 1, and 2 combined. CITEPOST is the number of non-self-citations per patent a firm files for and is eventually granted in post-IPO years 0, 1, and 2 combined. MQF is the management quality factor score obtained using common factor analysis on the firm-size-, firm-age-, and industry-dummies-adjusted TSIZE, MBA, FTEAM, LAWACC, CPA, CORE, FCEO, and BOARDS. TENURE is the average number of years a firm's management team members have been with the firm. TENHET is the coefficient of variation of the management team members' tenures. LNSIZE is the natural logarithm of the book value of assets immediately prior to the IPO. LNAGE is the firm age defined as the natural logarithm of one plus the firm age. ODIR is the proportion of outside directors in the board of directors. INSIDERA is the proportion of voting power owned by firm officers and directors immediately after the IPO. BOSS is an indicator variable equal to one if a CEO is also a Chairman of the board of directors, and zero otherwise. RDASSETS is R&D expenses scaled by firm assets in the IPO year. CAPEXASSETS is capital expenditure scaled by firm assets in the IPO year. ROA is net income scaled by firm assets in the IPO year. INSTP is the percentage of institutional stock holdings immediately after the IPO. All regressions include industry dummies. Standard errors are clustered at industry level. Standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)
	Pre-IPO innovation		Post-IPO innovation	
Dependent Variables	LNCOUNTPRE	LNCITEPRE	LNCOUNTPOST	LNCITEPOST
Constant	-1.087***	-0.862***	-0.842	2.506***
	(0.306)	(0.287)	(0.547)	(0.726)
MQF	0.068***	0.112***	0.108***	0.128***
	(0.024)	(0.026)	(0.033)	(0.040)
TENURE	-0.003	-0.012	-0.057***	-0.061***
	(0.003)	(0.008)	(0.018)	(0.011)
TENHET	-0.011	-0.020*	0.055	0.032
	(0.007)	(0.011)	(0.047)	(0.064)
LNSIZE	0.067***	0.056***	0.044	-0.123**
	(0.017)	(0.016)	(0.028)	(0.046)
LNAGE	-0.020	-0.007	-0.010	0.051
	(0.024)	(0.040)	(0.040)	(0.066)
ODIR	-0.018	0.069	0.224	0.248
	(0.031)	(0.052)	(0.219)	(0.235)
INSIDERA	0.044	0.150**	0.018	-0.150
	(0.068)	(0.069)	(0.165)	(0.132)
BOSS	-0.054***	-0.072*	-0.031	-0.047
	(0.016)	(0.040)	(0.052)	(0.032)
RDASSETS	0.362*	0.409	1.287***	0.927**
	(0.202)	(0.284)	(0.436)	(0.368)
CAPEXASSETS	-0.240	-0.150	-0.091	-0.067
	(0.160)	(0.151)	(0.363)	(0.319)
ROA	-0.025	-0.001	0.395**	0.601***
	(0.047)	(0.090)	(0.153)	(0.104)
INSTP	0.039	0.028	-0.194	-0.198
	(0.061)	(0.085)	(0.196)	(0.292)
Industry Dummies	Yes	Yes	Yes	Yes
N	1,725	1,725	1,712	1,712
R^2	0.113	0.077	0.255	0.196

Table 4. Relationship between individual management quality proxies and pre-IPO innovation

The sample consists of 1,851 venture-backed IPOs conducted between 1993 and 2004. TSIZE is the size of a firm's management team, defined as the number of executive officers with a rank of vice president or higher. PMBA is the percentage of a firm's management team with MBA degrees. PCPA is the percentage of a firm's management team who are Certified Public Accountants. PFTEAM is the percentage of a firm's management team who have served as executive officers and/or vice presidents prior to joining the IPO firm. PCORE is the percentage of a firm's management team who have core functional expertise, namely, holding positions in operations and production, sales and marketing, R&D, and finance. PLAWACC is the percentage of a firm's management team who have previously been partners in law or accounting firms. FCEO is the ratio of CEO salary and bonus to the average salary and bonus of other management team members in the fiscal year preceding the IPO. BOARDS is the number of other companies' boards that management team members sit on. TENURE is the average number of years a firm's management team members have been with the firm. TENHET is the coefficient of variation of the management team members' tenures. LNSIZE is the natural logarithm of the book value of the firm's assets immediately before the IPO. LNAGE is the firm age defined as the natural logarithm of one plus the firm age. ODIR is the percentage of outside directors in the board of directors. INSIDERA is the proportion of voting power owned by firm officers and directors immediately after the IPO. BOSS is an indicator variable equal to one if a CEO is also a Chairman of the board of directors, and zero otherwise. INSTP is the percentage of institutional stock holdings immediately after the IPO. RDASSETS is R&D expenses scaled by firm assets in year 0. CAPEXASSETS is capital expenditure scaled by firm assets in year 0. ROA is net income scaled by firm assets in year 0. All regressions include industry dummies. Standard errors are clustered at industry level. Standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

Panel A: Relationship between individual management quality proxies and the quantity of pre-IPO innovation

This panel presents multivariate OLS regressions of LNCOUNTPRE, which is the natural logarithm of the number of patents a firm files for and is eventually granted in pre-IPO years -1 and -2 combined on management quality variables and other control variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	-1.051***	-1.237***	-1.249***	-1.261***	-1.261***	-1.268***	-1.248***	-1.255***	-1.254***	-1.238***
	(0.291)	(0.350)	(0.354)	(0.359)	(0.337)	(0.352)	(0.361)	(0.370)	(0.359)	(0.348)
TSIZE	0.025***									
	(0.009)									
PMBA		0.087								
		(0.059)								
PCPA			0.071							
			(0.120)							
PFTEAM				0.026						
				(0.052)						
PCORE					0.015					
					(0.064)					
PLAWACC						-0.199*				
						(0.107)				
FCEO							0.006			
							(0.035)			
BOARDS								-0.005		
								(0.016)		
TENURE									-0.006**	
									(0.003)	
TENHET										-0.009
										(0.006)
LNSIZE	0.051***	0.066***	0.067***	0.066***	0.067***	0.068***	0.066***	0.067***	0.069***	0.066***
	(0.014)	(0.018)	(0.018)	(0.018)	(0.017)	(0.018)	(0.017)	(0.019)	(0.018)	(0.018)
LNAGE	-0.029	-0.032*	-0.034*	-0.032	-0.034*	-0.035*	-0.035*	-0.034*	-0.019	-0.032
	(0.020)	(0.019)	(0.020)	(0.022)	(0.020)	(0.020)	(0.018)	(0.019)	(0.023)	(0.019)
ODIR	0.006	-0.010	-0.003	-0.008	-0.008	-0.008	-0.006	-0.007	-0.010	-0.011
	(0.027)	(0.028)	(0.028)	(0.026)	(0.025)	(0.026)	(0.026)	(0.029)	(0.026)	(0.028)
INSIDERA	0.034	0.043	0.043	0.043	0.043	0.041	0.042	0.041	0.044	0.045
	(0.066)	(0.066)	(0.067)	(0.066)	(0.066)	(0.068)	(0.067)	(0.064)	(0.068)	(0.067)
BOSS	-0.055***	-0.056***	-0.056***	-0.057***	-0.057***	-0.058***	-0.057***	-0.056***	-0.055***	-0.056***
	(0.016)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.018)	(0.017)	(0.016)	(0.016)
INSTP	0.022	0.027	0.022	0.024	0.021	0.024	0.020	0.021	0.034	0.021
	(0.060)	(0.065)	(0.064)	(0.065)	(0.065)	(0.064)	(0.064)	(0.064)	(0.065)	(0.065)
RDASSETS	0.363*	0.363*	0.370*	0.370*	0.366*	0.364*	0.368*	0.370*	0.374*	0.368*
	(0.206)	(0.207)	(0.210)	(0.208)	(0.214)	(0.211)	(0.209)	(0.216)	(0.207)	(0.210)
CAPEXASSETS	-0.255	-0.201	-0.206	-0.197	-0.204	-0.206	-0.202	-0.205	-0.216	-0.197
	(0.177)	(0.188)	(0.191)	(0.199)	(0.190)	(0.191)	(0.196)	(0.192)	(0.181)	(0.187)
ROA	-0.031	-0.054	-0.057	-0.054	-0.057	-0.056	-0.057	-0.057	-0.051	-0.056
	(0.047)	(0.054)	(0.055)	(0.055)	(0.052)	(0.055)	(0.055)	(0.056)	(0.054)	(0.054)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,725	1,725	1,725	1,725	1,725	1,725	1,725	1,725	1,725	1,725
R^2	0.112	0.103	0.102	0.102	0.102	0.103	0.102	0.102	0.103	0.102

Table 4 (continued)

Panel B: Relationship between individual management quality proxies and the quality of pre-IPO innovation
This panel presents multivariate OLS regressions of LNCITEPRE, which is the natural logarithm of the number of non-self-citations per patent a firm files for and is eventually granted in pre-IPO years -1 and -2 combined on management quality variables and other control variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	-0.813***	-1.095***	-1.109***	-1.141***	-1.271***	-1.139***	-1.129***	-1.115***	-1.136***	-1.097***
	(0.268)	(0.312)	(0.320)	(0.303)	(0.351)	(0.305)	(0.321)	(0.331)	(0.326)	(0.311)
TSIZE	0.039***									
	(0.010)									
PMBA		0.185*								
		(0.095)								
PCPA			-0.009							
			(0.213)							
PFTEAM				0.048						
				(0.045)						
PCORE					0.146**					
					(0.069)					
PLAWACC						-0.244***				
						(0.089)				
FCEO							0.026			
							(0.033)			
BOARDS								-0.003		
								(0.017)		
TENURE									-0.017***	
									(0.006)	
TENHET										-0.018*
										(0.010)
LNSIZE	0.029**	0.052***	0.053***	0.053***	0.060***	0.055***	0.052***	0.054***	0.059***	0.053***
	(0.014)	(0.016)	(0.016)	(0.016)	(0.017)	(0.016)	(0.016)	(0.017)	(0.017)	(0.016)
LNAGE	-0.039	-0.042	-0.047	-0.042	-0.047	-0.048	-0.049*	-0.047	-0.007	-0.041
	(0.028)	(0.027)	(0.029)	(0.031)	(0.028)	(0.029)	(0.028)	(0.029)	(0.039)	(0.026)
ODIR	0.114**	0.087	0.095	0.092*	0.075	0.093*	0.094*	0.095*	0.083	0.084
	(0.054)	(0.056)	(0.059)	(0.055)	(0.050)	(0.054)	(0.054)	(0.054)	(0.053)	(0.056)
INSIDERA	0.132*	0.146**	0.144**	0.146**	0.152**	0.143**	0.142**	0.144**	0.151**	0.150**
	(0.066)	(0.068)	(0.069)	(0.067)	(0.070)	(0.069)	(0.069)	(0.066)	(0.070)	(0.069)
BOSS	-0.075*	-0.077*	-0.078*	-0.078*	-0.079*	-0.080*	-0.080*	-0.078*	-0.075*	-0.077*
	(0.040)	(0.043)	(0.041)	(0.041)	(0.042)	(0.042)	(0.041)	(0.041)	(0.041)	(0.041)
INSTP	-0.013	-0.003	-0.015	-0.010	-0.011	-0.011	-0.017	-0.015	0.019	-0.014
	(0.074)	(0.072)	(0.077)	(0.076)	(0.075)	(0.074)	(0.075)	(0.076)	(0.091)	(0.076)
RDASSETS	0.403	0.400	0.411	0.416	0.391	0.407	0.412	0.413	0.428	0.412
	(0.290)	(0.294)	(0.299)	(0.296)	(0.290)	(0.297)	(0.296)	(0.300)	(0.292)	(0.297)
CAPEXASSETS	-0.160	-0.074	-0.081	-0.069	-0.078	-0.083	-0.073	-0.082	-0.112	-0.068
	(0.161)	(0.164)	(0.163)	(0.168)	(0.168)	(0.166)	(0.170)	(0.165)	(0.151)	(0.162)
ROA	-0.019	-0.052	-0.058	-0.053	-0.068	-0.058	-0.059	-0.058	-0.044	-0.057
	(0.093)	(0.092)	(0.092)	(0.091)	(0.094)	(0.092)	(0.092)	(0.091)	(0.089)	(0.091)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,725	1,725	1,725	1,725	1,725	1,725	1,725	1,725	1,725	1,725
R^2	0.072	0.063	0.061	0.062	0.062	0.062	0.062	0.062	0.065	0.062

Table 5. Relationship between individual management quality proxies and post-IPO innovation

The sample consists of 1,851 venture-backed IPOs conducted between 1993 and 2004. TSIZE is the size of a firm's management team, defined as the number of executive officers with a rank of vice president or higher. PMBA is the percentage of a firm's management team with MBA degrees. PCPA is the percentage of a firm's management team who are Certified Public Accountants. PFTEAM is the percentage of a firm's management team who have served as executive officers and/or vice presidents prior to joining the IPO firm. PCORE is the percentage of a firm's management team who have core functional expertise, namely, holding positions in operations and production, sales and marketing, R&D, and finance. PLAWACC is the percentage of a firm's management team who have previously been partners in law or accounting firms. FCEO is the ratio of CEO salary and bonus to the average salary and bonus of other management team members in the fiscal year preceding the IPO. BOARDS is the number of other companies' boards that management team members sit on. TENURE is the average number of years a firm's management team members have been with the firm. TENHET is the coefficient of variation of the management team members' tenures. LNSIZE is the natural logarithm of the book value of the firm's assets immediately before the IPO. LNAGE is the firm age defined as the natural logarithm of one plus the firm age. ODIR is the percentage of outside directors in the board of directors. INSIDERA is the proportion of voting power owned by firm officers and directors immediately after the IPO. BOSS is an indicator variable equal to one if a CEO is also a Chairman of the board of directors, and zero otherwise. INSTP is the percentage of institutional stock holdings immediately after the IPO. RDASSETS is R&D expenses scaled by firm assets in year 0. CAPEXASSETS is capital expenditure scaled by firm assets in year 0. ROA is net income scaled by firm assets in year 0. All regressions include industry dummies. Standard errors are clustered at industry level. Standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

Panel A: Relationship between individual management quality proxies and the quantity of post-IPO innovation

This panel presents multivariate OLS regressions of LNCOUNTPOST, which is the natural logarithm of the number of patents a firm files for and is eventually granted in post-IPO years 0, 1, and 2 combined on management quality variables and other control variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	0.041	-0.096	-0.048	-0.144	-0.354	-0.160	-0.092	-0.066	-0.728	-0.139
	(0.625)	(0.628)	(0.647)	(0.622)	(0.697)	(0.629)	(0.634)	(0.584)	(0.539)	(0.636)
TSIZE	0.044***									
	(0.014)									
PMBA		0.414**								
		(0.205)								
PCPA			-0.454*							
			(0.265)							
PFTEAM				0.085						
				(0.142)						
PCORE					0.215					
					(0.136)					
PLAWACC						-0.473**				
						(0.180)				
FCEO							-0.066			
							(0.089)			
BOARDS								0.020		
								(0.035)		
TENURE									-0.060***	
									(0.016)	
TENHET										0.046
										(0.049)
LNSIZE	-0.003	0.022	0.023	0.023	0.034	0.027	0.028	0.022	0.043	0.026
	(0.029)	(0.030)	(0.031)	(0.030)	(0.034)	(0.030)	(0.032)	(0.026)	(0.029)	(0.029)
LNAGE	-0.107**	-0.102**	-0.113**	-0.105**	-0.113**	-0.113**	-0.107**	-0.112**	0.014	-0.127***
	(0.043)	(0.045)	(0.043)	(0.042)	(0.043)	(0.044)	(0.041)	(0.043)	(0.044)	(0.041)
ODIR	0.257	0.221	0.220	0.234	0.208	0.236	0.244	0.244	0.198	0.270
	(0.201)	(0.192)	(0.204)	(0.199)	(0.215)	(0.203)	(0.199)	(0.200)	(0.201)	(0.224)
INSIDERA	-0.008	0.005	0.003	0.007	0.014	-0.002	0.008	0.009	0.040	-0.010
	(0.171)	(0.167)	(0.173)	(0.167)	(0.168)	(0.171)	(0.170)	(0.164)	(0.168)	(0.166)
BOSS	-0.039	-0.040	-0.048	-0.044	-0.045	-0.048	-0.040	-0.047	-0.035	-0.046
	(0.055)	(0.059)	(0.057)	(0.058)	(0.059)	(0.059)	(0.057)	(0.058)	(0.056)	(0.057)
INSTP	-0.320*	-0.306	-0.341*	-0.321*	-0.326*	-0.324*	-0.326*	-0.331*	-0.212	-0.332*
	(0.188)	(0.183)	(0.189)	(0.185)	(0.183)	(0.184)	(0.182)	(0.184)	(0.198)	(0.185)
RDASSETS	1.262***	1.254***	1.269***	1.288***	1.248***	1.270***	1.282***	1.272***	1.318***	1.279***
	(0.443)	(0.421)	(0.453)	(0.446)	(0.446)	(0.448)	(0.448)	(0.449)	(0.447)	(0.442)
CAPEXASSETS	0.028	0.094	0.072	0.088	0.068	0.066	0.045	0.077	-0.046	0.037
	(0.366)	(0.373)	(0.378)	(0.383)	(0.374)	(0.377)	(0.386)	(0.380)	(0.368)	(0.362)
ROA	0.345**	0.318**	0.307*	0.311*	0.287*	0.301*	0.309**	0.305*	0.355**	0.300*
	(0.156)	(0.157)	(0.157)	(0.167)	(0.163)	(0.155)	(0.148)	(0.154)	(0.151)	(0.153)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,712	1,712	1,712	1,712	1712	1,712	1,712	1712	1,712	1,712
R^2	0.232	0.229	0.227	0.225	0.226	0.226	0.226	0.225	0.247	0.226

Table 5 (continued)

Panel B: Relationship between individual management quality proxies and the quality of post-IPO innovation
This panel presents multivariate OLS regressions of LNCITEPOST, which is the natural logarithm of the number of non-self-citations per patent a firm files for and is eventually granted in post-IPO years 0, 1, and 2 combined on management quality variables and other control variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	3.451***	3.329***	3.395***	3.226***	2.504***	3.173***	3.339***	3.372***	2.599***	3.308***
	(0.769)	(0.723)	(0.737)	(0.718)	(0.893)	(0.707)	(0.727)	(0.683)	(0.693)	(0.715)
TSIZE	0.039**									
	(0.015)									
PMBA		0.272								
		(0.227)								
PCPA			-0.596*							
			(0.355)							
PFTEAM				0.196*						
				(0.110)						
PCORE					0.698***					
					(0.219)					
PLAWACC						-1.199***				
						(0.351)				
FCEO							-0.111			
							(0.165)			
BOARDS								0.027		
								(0.035)		
TENURE									-0.065***	
									(0.010)	
TENHET										0.023
										(0.067)
LNSIZE	-0.167***	-0.144***	-0.145***	-0.146***	-0.112*	-0.135***	-0.137**	-0.147***	-0.122**	-0.143***
	(0.050)	(0.048)	(0.049)	(0.049)	(0.057)	(0.048)	(0.052)	(0.045)	(0.046)	(0.047)
LNAGE	-0.063	-0.061	-0.068	-0.050	-0.069	-0.070	-0.059	-0.067	0.070	-0.075
	(0.074)	(0.076)	(0.075)	(0.077)	(0.072)	(0.075)	(0.065)	(0.075)	(0.073)	(0.063)
ODIR	0.298	0.271	0.257	0.268	0.179	0.273	0.290	0.289	0.238	0.299
	(0.202)	(0.201)	(0.214)	(0.205)	(0.222)	(0.209)	(0.203)	(0.203)	(0.207)	(0.237)
INSIDERA	-0.184	-0.173	-0.175	-0.166	-0.139	-0.188	-0.166	-0.166	-0.134	-0.181
	(0.159)	(0.161)	(0.161)	(0.156)	(0.159)	(0.161)	(0.160)	(0.164)	(0.136)	(0.164)
BOSS	-0.059*	-0.061	-0.067*	-0.063*	-0.063	-0.072*	-0.055	-0.066*	-0.053	-0.064*
	(0.034)	(0.037)	(0.036)	(0.037)	(0.038)	(0.038)	(0.036)	(0.038)	(0.035)	(0.036)
INSTP	-0.339	-0.333	-0.362	-0.326	-0.332	-0.330	-0.341	-0.349	-0.220	-0.350
	(0.277)	(0.277)	(0.281)	(0.280)	(0.263)	(0.273)	(0.266)	(0.273)	(0.292)	(0.274)
RDASSETS	0.905**	0.904**	0.907**	0.938**	0.815**	0.895**	0.925**	0.910**	0.962**	0.921**
	(0.394)	(0.390)	(0.403)	(0.394)	(0.373)	(0.392)	(0.397)	(0.393)	(0.370)	(0.394)
CAPEXASSETS	0.053	0.105	0.093	0.134	0.088	0.082	0.050	0.099	-0.036	0.073
	(0.326)	(0.337)	(0.339)	(0.349)	(0.335)	(0.326)	(0.356)	(0.323)	(0.324)	(0.311)
ROA	0.532***	0.505***	0.501***	0.516***	0.448***	0.492***	0.507***	0.499***	0.553***	0.493***
	(0.104)	(0.113)	(0.110)	(0.113)	(0.120)	(0.109)	(0.101)	(0.104)	(0.107)	(0.107)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,712	1,712	1,712	1,712	1,712	1,712	1,712	1,712	1712	1712
R^2	0.179	0.177	0.177	0.177	0.182	0.179	0.177	0.176	0.191	0.176

Table 6. Instrumental variable 2-SLS regression analysis of the effect of management quality on pre- and post-IPO innovation

The sample consists of 1,851 venture-backed IPOs conducted between 1993 and 2004. In first stage regressions MQF is the management quality factor score obtained using common factor analysis on the firm-size-, firm-age-, and industry-dummies-adjusted TSIZE, MBA, FTEAM, LAWACC, CPA, CORE, FCEO, and BOARDS. In second stage regressions MQFHAT is the predicted value of MQF from the first stage regressions. LNCOUNTPRE, LNCITEPRE, LNCOUNTPOST, and LNCITEPOST are the natural logarithms of one plus COUNTPRE, CITEPRE, COUNTPOST, and CITEPOST, respectively. COUNTPRE is the number of patents a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. CITEPRE is the number of non-self-citations per patent a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. COUNTPOST is the number of patents a firm files for and is eventually granted in post-IPO years 0, 1, and 2 combined. CITEPOST is the number of non-self-citations per patent a firm files for and is eventually granted in post-IPO years 0, 1, and 2 combined. EDUC is the percentage of population with bachelor's degree or higher in the same three-digit zip code area where IPO firm's headquarters is located. TENURE is the average number of years a firm's management team members have been with the firm. TENHET is the coefficient of variation of the management team members' tenures. LNSIZE is the natural logarithm of the book value of the firm's assets immediately before the IPO. LNAGE is the firm age defined as the natural logarithm of one plus the firm age. ODIR is the percentage of outside directors in the board of directors. INSIDERA is the proportion of voting power owned by firm officers and directors immediately after the IPO. BOSS is an indicator variable equal to one if a CEO is also a Chairman of the board of directors, and zero otherwise. INSTP is the percentage of institutional stock holdings immediately after the IPO. RDASSETS is R&D expenses scaled by firm assets in year 0. CAPEXASSETS is capital expenditure scaled by firm assets in year 0. ROA is net income scaled by firm assets in year 0. All regressions include industry dummies. Standard errors are clustered at industry-level. Standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

	First Stage	Second Stage		First Stage	Second Stage	
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variables	MQF	LNCOUNTPRE	LNCITEPCTPRE	MQF	LNCOUNTPOST	LNCITEPCTPOST
Constant	-0.422	-1.246	-1.066	-0.259	-0.685	2.946*
	(0.958)	(0.777)	(0.985)	(0.946)	(1.268)	(1.560)
EDUC	0.012***			0.012***		
	(0.003)			(0.003)		
MQFHAT		0.570***	0.512**		0.773**	0.577
		(0.186)	(0.236)		(0.321)	(0.394)
TENURE	-0.047***	0.021*	0.008	-0.042***	-0.028*	-0.041**
	(0.008)	(0.011)	(0.014)	(0.007)	(0.017)	(0.021)
TENHET	0.041	-0.033	-0.037	0.040	0.026	0.013
	(0.026)	(0.023)	(0.029)	(0.026)	(0.037)	(0.046)
LNSIZE	0.013	0.056***	0.047**	0.007	0.036	-0.128***
	(0.018)	(0.015)	(0.019)	(0.018)	(0.024)	(0.030)
LNAGE	0.058	-0.038	-0.022	0.080**	-0.052	0.022
	(0.039)	(0.032)	(0.041)	(0.035)	(0.051)	(0.063)
ODIR	0.000	-0.039	0.052	0.058	0.157	0.203
	(0.128)	(0.103)	(0.131)	(0.126)	(0.171)	(0.210)
INSIDERA	0.047	0.020	0.131	0.034	-0.006	-0.167
	(0.110)	(0.089)	(0.113)	(0.109)	(0.146)	(0.180)
BOSS	-0.022	-0.043	-0.063	-0.060	0.008	-0.020
	(0.044)	(0.035)	(0.045)	(0.043)	(0.061)	(0.075)
INSTP	-0.083	0.078	0.059	-0.166	-0.089	-0.128
	(0.151)	(0.123)	(0.156)	(0.149)	(0.206)	(0.253)
RDASSETS	0.127	0.278	0.341	0.220	1.113***	0.810**
	(0.207)	(0.170)	(0.216)	(0.207)	(0.290)	(0.357)
CAPEXASSETS	0.477	-0.462*	-0.328	0.069	-0.113	-0.081
	(0.311)	(0.265)	(0.336)	(0.308)	(0.412)	(0.507)
ROA	-0.369***	0.169*	0.154	-0.358***	0.648***	0.771***
	(0.091)	(0.103)	(0.130)	(0.096)	(0.177)	(0.218)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	1,725	1,725	1,725	1,712	1,712	1,712
R^2	0.096			0.086		
F-Test (1st Stage)	18.79			17.45		
p-value	0.0000			0.0000		

Table 7. Relation between pre-IPO innovation, management quality, and anti-takeover provisions

The sample consists of 1,851 venture-backed IPOs conducted between 1993 and 2004. This table presents Poisson maximum-likelihood regressions of ATPs on pre-IPO innovation, management quality, and other control variables. Dependent variable ATP is the total number of firm-level ATPs in a firm's corporate charter at IPO. LNCOUNTPRE and LNCITEPRE are the natural logarithms of one plus COUNTPRE and CITEPRE, respectively. COUNTPRE is the number of patents a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. CITEPRE is the number of non-self-citations per patent a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. MQFDUMMY is a binary variable that takes a value of one for firms with above median MQF score and zero otherwise. Q1 is a dummy variable which takes a value of one for firms with above MQF score and above median number of patents a firm files for and eventually is granted in in pre-IPO years -1 and -2 combined, and zero otherwise. LNRESCOUNT and LNRESCITE are the residuals from regressions of LNCOUNTPRE and LNCITEPRE, respectively, on MQFDUMMY, TENURE, and TENHET. LNRESCOUNT×MQF is the interaction of LNRESCOUNT and MQFDUMMY, and LNRESCITE×MQF is the interaction of LNRESCITE and MQFDUMMY. TENURE is the average number of years a firm's management team members have been with the firm. TENHET is the coefficient of variation of the management team members' tenures. LNSIZE is the natural logarithm of the book value of assets immediately prior to the IPO. LNAGE is the firm age defined as the natural logarithm of one plus the firm age. ODIR is the proportion of outside directors in the board of directors. INSIDERA is the proportion of voting power owned by firm officers and directors immediately after the IPO. BOSS is an indicator variable equal to one if a CEO is also a Chairman of the board of directors, and zero otherwise. INSTP is the percentage of institutional stock holdings immediately after the IPO. RDASSETS is R&D expenses scaled by firm assets in the IPO year. CAPEXASSETS is capital expenditure scaled by firm assets in the IPO year. ROA is net income scaled by firm assets in the IPO year. All regressions include industry dummies. Standard errors are clustered at industry-level. Standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Dependent Variables	ATP	ATP	ATP	ATP	ATP
Constant	0.151	0.071	0.146	0.131	0.043
	(0.352)	(0.357)	(0.333)	(0.318)	(0.325)
LNCOUNTPRE	0.073***				
	(0.015)				
LNCITEPRE		0.032*			
		(0.018)			
Q1			0.091**		
			(0.036)		
LNRESCOUNT×MQF				-0.055***	
				(0.016)	
LNRESCOUNT				0.103***	
				(0.020)	
LNRESCITE×MQF					-0.045***
					(0.015)
LNRESCITE					0.061***
					(0.023)
MQFDUMMY				0.088***	0.086***
				(0.021)	(0.022)
TENURE			0.006	0.010**	0.009*
			(0.005)	(0.005)	(0.005)
TENHET			0.016**	0.014*	0.015*
			(0.008)	(0.008)	(0.008)
LNSIZE	0.067***	0.070***	0.065***	0.065***	0.069***
	(0.014)	(0.014)	(0.013)	(0.013)	(0.013)
LNAGE	-0.025	-0.025	-0.017	-0.051*	-0.051**
	(0.020)	(0.020)	(0.020)	(0.026)	(0.026)
ODIR	0.168**	0.165**	0.197***	0.181**	0.179**
	(0.078)	(0.081)	(0.075)	(0.077)	(0.080)
INSIDERA	0.086	0.082	0.067	0.070	0.067
	(0.067)	(0.067)	(0.060)	(0.066)	(0.065)
BOSS	0.036	0.034	0.035	0.036	0.034
	(0.031)	(0.031)	(0.032)	(0.031)	(0.030)
INSTP	0.377***	0.377***	0.361***	0.358***	0.354***
	(0.068)	(0.070)	(0.070)	(0.064)	(0.066)
RDASSETS	-0.205	-0.188	-0.210*	-0.223	-0.210*
	(0.137)	(0.127)	(0.121)	(0.136)	(0.126)
CAPEXASSETS	0.164	0.154	0.167	0.159	0.140
	(0.191)	(0.194)	(0.195)	(0.174)	(0.179)
ROA	-0.095***	-0.097***	-0.119***	-0.091***	-0.093***
	(0.032)	(0.032)	(0.028)	(0.030)	(0.030)
Industry Dummies	Yes	Yes	Yes	Yes	Yes
N	1,725	1,725	1,806	1,725	1,725

Table 8. Relationship between pre-IPO innovation, management quality, and IPO firm valuation

The sample consists of 1,851 venture-backed IPOs conducted between 1993 and 2004. QOP and QFTD are two definitions of Tobin's Q. Tobin's Q is the ratio of the market value of assets to the book value of assets, where the market value of assets is equal to the book value of assets minus the book value of common equity plus the number of shares outstanding times the market price (either IPO offer price (for QOP) or first trading day closing price (for QFTD)) or times the share price at the end of the issue month (for industry peers). LNCOUNTPRE and LNCITEPRE are the natural logarithms of one plus COUNTPRE and CITEPRE, respectively. COUNTPRE is the number of patents a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. CITEPRE is the number of non-self-citations per patent a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. LNSIZE is the natural logarithm of the book value of assets immediately prior to the IPO. LNAGE is the firm age defined as the natural logarithm of one plus the firm age. ODIR is the proportion of outside directors in the board of directors. INSIDERA is the proportion of voting power owned by firm officers and directors immediately after the IPO. BOSS is an indicator variable equal to one if a CEO is also a Chairman of the board of directors, and zero otherwise. INSTP is the percentage of institutional stock holdings immediately after the IPO. RDASSETS is R&D expenses scaled by firm assets in the IPO year. CAPEXASSETS is capital expenditure scaled by firm assets in the IPO year. ROA is net income scaled by firm assets in the IPO year. All regressions include industry dummies. Standard errors are clustered at industry-level. Standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

Panel A: Relationship between pre-IPO innovation and IPO firm valuation

This panel presents quantile/median regressions of IPO firm valuation measures on pre-IPO innovation proxies and other control variables.

	(1)	(2)	(3)	(4)
Dependent Variables	QOP	QFTD	QOP	QFTD
Constant	4.543***	5.176**	4.221***	4.849*
	(1.362)	(2.338)	(1.374)	(2.527)
LNCOUNTPRE	0.190***	0.394***		
	(0.054)	(0.093)		
LNCITEPRE			0.143***	0.188***
			(0.038)	(0.069)
LNSIZE	-0.174***	-0.199***	-0.154***	-0.180***
	(0.027)	(0.046)	(0.027)	(0.049)
LNAGE	-0.134***	-0.314***	-0.149***	-0.313***
	(0 .050)	(0.086)	(0.051)	(0.093)
ODIR	0.107	0.110	0.050	0.098
	(0.184)	(0.316)	(0.186)	(0.342)
INSIDERA	0.794***	1.137***	0.780***	1.111***
	(0.159)	(0.273)	(0.161)	(0.296)
BOSS	0.119*	0.081	0.122*	0.083
	(0.064)	(0.109)	(0.064)	(0.118)
INSTP	-1.408***	-1.334***	-1.510***	-1.381***
	(0.219)	(0.375)	(0.221)	(0.406)
RDASSETS	0.545*	-0.061	0.535*	-0.058
	(0.304)	(0.522)	(0.307)	(0.564)
CAPEXASSETS	-0.363	-0.629	-0.324	-0.589
	(0.459)	(0.787)	(0.463)	(0.851)
ROA	-0.704***	-0.994***	-0.720***	-1.122***
	(0.134)	(0.230)	(0.135)	(0.249)
Industry Dummies	Yes	Yes	Yes	Yes
N	1,692	1,692	1,692	1,692

Table 8 (continued)

Panel B: Relationship between pre-IPO innovation, management quality, and IPO firm valuation,

This panel presents quantile/median regressions of IPO firm valuation measures on pre-IPO innovation proxies, management quality dummy, and other control variables. Q1 is a dummy variable which takes a value of one for firms with above MQF score and above median number of patents a firm files for and eventually is granted in in pre-IPO years -1 and -2 combined, and zero otherwise. MQFDUMMY is a binary variable that takes a value of one for firms with above median MQF score and zero otherwise. COUNTPRE is the number of patents a firm files and eventually gets granted in pre-IPO years -1 and -2 combined. CITEPRE is the number of non-self-citations per patent in pre-IPO years -1 and -2 combined. LNCOUNTPRE and LNCITEPRE are the natural logarithms of one plus COUNTPRE and CITEPRE, respectively. LNRESCOUNT and LNRESCITE are the residuals from regressions of LNCOUNTPRE and LNCITEPRE, respectively, on MQFDUMMY, TENURE, and TENHET. LNRESCOUNT×MQF is the interaction of LNRESCOUNT and MQFDUMMY, and LNRESCITE×MQF is the interaction of LNRESCITE and MQFDUMMY. TENURE is the average number of years a firm's management team members have been with the firm. TENHET is the coefficient of variation of the management team members' tenures.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variables	QOP	QFTD	QOP	QFTD	QOP	QFTD
Constant	4.751***	4.644**	4.241***	4.817**	4.154***	4.605**
	(1.373)	(2.267)	(1.354)	(2.225)	(1.311)	(2.343)
Q1	0.435***	0.697***				
	(0.105)	(0.173)				
LNRESCOUNT×MQF			-0.033	0.197		
			(0.109)	(0.179)		
LNRESCOUNT			0.194**	0.148		
			(0.088)	(0.145)		
LNRESCITE×MQF					0.056	0.275**
					(0.077)	(0.138)
LNRESCITE					0.091	0.055
					(0.065)	(0.116)
MQFDUMMY			0.216***	0.373***	0.247***	0.444***
			(0.063)	(0.103)	(0.061)	(0.109)
TENURE	-0.029***	-0.038**	-0.023**	-0.041**	-0.021**	-0.041**
	(0.011)	(0.018)	(0.011)	(0.018)	(0.011)	(0.019)
TENHET	0.057	-0.004	0.038	-0.001	0.028	0.011
	(0.039)	(0.064)	(0.038)	(0.063)	(0.037)	(0.066)
LNSIZE	-0.155***	-0.173***	-0.157***	-0.173***	-0.148***	-0.159***
	(0.026)	(0.043)	(0.027)	(0.044)	(0.026)	(0.046)
LNAGE	-0.041	-0.151*	-0.117**	-0.254***	-0.134**	-0.234**
	(0.051)	(0.085)	(0.057)	(0.093)	(0.055)	(0.098)
ODIR	0.134	0.163	0.184	0.084	0.107	0.044
	(0.183)	(0.302)	(0.184)	(0.303)	(0.179)	(0.320)
INSIDERA	0.905***	1.303***	0.921***	1.274***	0.856***	1.215***
	(0.157)	(0.259)	(0.159)	(0.261)	(0.154)	(0.276)
BOSS	0.112*	0.082	0.118*	0.092	0.100	0.060
	(0.063)	(0.104)	(0.063)	(0.104)	(0.061)	(0.110)
INSTP	-1.452***	-1.421***	-1.461***	-1.409***	-1.557***	-1.337***
	(0.215)	(0.354)	(0.218)	(0.359)	(0.212)	(0.378)
RDASSETS	0.663**	0.102	0.451	0.015	0.474	-0.056
	(0.303)	(0.500)	(0.303)	(0.498)	(0.293)	(0.524)
CAPEXASSETS	-0.256	-0.617	-0.634	-1.215	-0.792*	-1.272
	(0.450)	(0.744)	(0.457)	(0.751)	(0.443)	(0.792)
ROA	-0.703***	-0.908***	-0.673***	-0.867***	-0.667***	-1.071***
	(0.131)	(0.217)	(0.133)	(0.219)	(0.129)	(0.231)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	1,769	1,769	1,692	1,692	1,692	1,692

Table 9. Relationship between pre-IPO innovation, management quality, and firm age at IPO

The sample consists of 1,851 venture-backed IPOs conducted between 1993 and 2004. This table presents multivariate ordinary least squares (OLS) regressions of firm age on pre-IPO innovation proxies, management quality, and other control variables. AGE is the firm age at IPO in years. LNCOUNTPRE and LNCITEPRE are the natural logarithms of one plus COUNTPRE and CITEPRE, respectively. COUNTPRE is the number of patents a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. CITEPRE is the number of non-self-citations per patent a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. MQFDUMMY is a binary variable that takes a value of one for firms with above median MQF score and zero otherwise. Q1 is a dummy variable which takes a value of one for firms with above MQF score and above median number of patents a firm files for and eventually is granted in in pre-IPO years -1 and -2 combined, and zero otherwise. LNRESCOUNT and LNRESCITE are the residuals from regressions of LNCOUNTPRE and LNCITEPRE, respectively, on MQFDUMMY, TENURE, and TENHET. LNRESCOUNT×MQF is the interaction of LNRESCOUNT and MQFDUMMY, and LNRESCITE×MQF is the interaction of LNRESCITE and MQFDUMMY. TENURE is the average number of years a firm's management team members have been with the firm. TENHET is the coefficient of variation of the management team members' tenures. LNSIZE is the natural logarithm of the book value of assets immediately prior to the IPO. LNAGE is the firm age defined as the natural logarithm of one plus the firm age. ODIR is the proportion of outside directors in the board of directors. INSIDERA is the proportion of voting power owned by firm officers and directors immediately after the IPO. BOSS is an indicator variable equal to one if a CEO is also a Chairman of the board of directors, and zero otherwise. INSTP is the percentage of institutional stock holdings immediately after the IPO. RDASSETS is R&D expenses scaled by firm assets in the IPO year. CAPEXASSETS is capital expenditure scaled by firm assets in the IPO year. ROA is net income scaled by firm assets in the IPO year. All regressions include industry dummies. Standard errors are clustered at industry-level. Standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Dependent Variables	AGE	AGE	AGE	AGE	AGE
Constant	-41.080***	-40.387***	-27.786***	-39.911***	-39.304***
	(10.540)	(10.448)	(7.852)	(9.919)	(9.798)
LNCOUNTPRE	-0.987**				
	(0.464)				
LNCITEPRE		-0.483**			
		(0.207)			
Q1			-1.325**		
			(0.520)		
LNRESCOUNT×MQF				-0.173	
				(0.886)	
LNRESCOUNT				-0.510	
				(0.889)	
LNRESCITE×MQF					0.445
					(0.524)
LNRESCITE					-0.435
					(0.388)
MQFDUMMY				0.101	0.113
				(0.666)	(0.686)
TENURE			1.344***	1.336***	1.343***
			(0.286)	(0.285)	(0.287)
TENHET			1.418***	1.329***	1.324***
			(0.450)	(0.426)	(0.430)
LNSIZE	2.664***	2.625***	1.766***	1.986***	1.954***
	(0.549)	(0.545)	(0.436)	(0.474)	(0.470)
ODIR	-5.529***	-5.481***	-2.199	-2.459	-2.434
	(1.949)	(1.958)	(1.666)	(1.782)	(1.778)
INSIDERA	-4.467**	-4.442**	-4.736**	-4.552**	-4.604**
	(2.115)	(2.134)	(2.172)	(2.128)	(2.166)
BOSS	1.233*	1.252*	0.835	0.801	0.836
	(0.678)	(0.683)	(0.726)	(0.703)	(0.710)
RDASSETS	5.027*	4.869*	1.715	1.491	1.346
	(2.641)	(2.580)	(2.798)	(2.896)	(2.893)
CAPEXASSETS	-8.356	-8.195	-6.098	-6.685	-6.377
	(6.165)	(6.159)	(4.676)	(5.064)	(4.980)
ROA	5.837***	5.872***	2.613**	2.634**	2.656**
	(1.068)	(1.073)	(1.034)	(1.086)	(1.071)
INSTP	0.515	0.491	-3.150	-3.249	-3.240
	(2.839)	(2.818)	(2.921)	(3.137)	(3.110)
Industry Dummies	Yes	Yes	Yes	Yes	Yes
N	1,725	1,725	1,806	1,725	1,725
R^2	0.305	0.304	0.373	0.385	0.384

Table 10. Relationship between pre-IPO innovation and post-IPO operating performance

The sample consists of 1,851 venture-backed IPOs conducted between 1993 and 2004. OIBDA is the ratio of operating income before depreciation plus interest income (Compustat items 13 and 62, respectively) to the book value of total assets (item 6). OIBDA is adjusted for industry performance by subtracting contemporaneous industry (2-digit SIC code) medians. Year 0 is the year of IPO. ΔOBIDA -1 to 0, ΔOBIDA -1 to 1, ΔOBIDA -1 to 2 and ΔOBIDA -1 to 3 are the changes in post-IPO operating performance from year -1 to years 0, 1, 2, and 3, respectively. LNCOUNTPRE and LNCITEPRE are the natural logarithms of one plus COUNTPRE and CITEPRE, respectively. COUNTPRE is the number of patents a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. CITEPRE is the number of non-self-citations per patent a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. LNSIZE is the natural logarithm of the book value of assets immediately prior to the IPO. LNAGE is the firm age defined as the natural logarithm of one plus the firm age. ODIR is the proportion of outside directors in the board of directors. INSIDERA is the proportion of voting power owned by firm officers and directors immediately after the IPO. BOSS is an indicator variable equal to one if a CEO is also a Chairman of the board of directors, and zero otherwise. INSTP is the percentage of institutional stock holdings immediately after the IPO. RDASSETS is R&D expenses scaled by firm assets in the IPO year. CAPEXASSETS is capital expenditure scaled by firm assets in the IPO year. ROA is net income scaled by firm assets in the IPO year. All regressions include industry dummies. Standard errors are clustered at industry-level. All specifications (1) through (8) are estimated using quantile/median regressions. Standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variables	ΔOIBDA -1 to 0	ΔOIBDA -1 to 1	ΔOIBDA -1 to 2	ΔOIBDA -1 to 3	ΔOIBDA -1 to 0	ΔOIBDA -1 to 1	ΔOIBDA -1 to 2	ΔOIBDA -1 to 3
Constant	0.523	0.230	0.262	0.341	0.216	0.216	0.236	0.342
	(0.338)	(0.414)	(0.380)	(0.445)	(0.414)	(0.414)	(0.378)	(0.454)
LNCOUNTPRE	0.030**	0.041**	0.036**	0.019				
	(0.014)	(0.017)	(0.016)	(0.019)				
LNCITEPRE					0.024**	0.024**	0.031***	0.025*
					(0.011)	(0.011)	(0.011)	(0.013)
LNSIZE	-0.021***	-0.013	-0.014*	-0.015	-0.012	-0.012	-0.012	-0.015
	(0.007)	(0.008)	(0.008)	(0.010)	(0.008)	(0.008)	(0.008)	(0.010)
LNAGE	-0.037***	-0.023	-0.016	-0.023	-0.025	-0.025	-0.017	-0.021
	(0.012)	(0.015)	(0.015)	(0.018)	(0.016)	(0.016)	(0.015)	(0.019)
ODIR	0.146***	0.151***	0.106*	0.116*	0.140**	0.140**	0.087	0.112
	(0.045)	(0.056)	(0.055)	(0.066)	(0.056)	(0.056)	(0.054)	(0.068)
INSIDERA	-0.027	-0.010	-0.005	-0.039	-0.003	-0.003	-0.006	-0.030
	(0.039)	(0.050)	(0.048)	(0.059)	(0.050)	(0.050)	(0.048)	(0.061)
BOSS	-0.012	-0.013	-0.003	-0.002	-0.013	-0.013	-0.007	-0.002
	(0.016)	(0.020)	(0.019)	(0.023)	(0.020)	(0.020)	(0.019)	(0.024)
INSTP	-0.003	0.011	0.013	0.038	0.012	0.012	-0.006	0.026
	(0.054)	(0.067)	(0.065)	(0.079)	(0.067)	(0.067)	(0.064)	(0.081)
RDASSETS	0.069	-0.143	-0.061	-0.043	-0.103	-0.103	-0.038	-0.050
	(0.074)	(0.094)	(0.090)	(0.110)	(0.094)	(0.094)	(0.090)	(0.112)
CAPEXASSETS	-0.280**	-0.239*	-0.115	-0.023	-0.238*	-0.238*	-0.161	-0.072
	(0.113)	(0.144)	(0.138)	(0.166)	(0.144)	(0.144)	(0.137)	(0.169)
ROA	-0.309***	-0.391***	-0.619***	-0.702***	-0.385***	-0.385***	-0.600***	-0.694***
	(0.033)	(0.044)	(0.044)	(0.054)	(0.044)	(0.044)	(0.044)	(0.056)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,702	1,565	1,407	1,255	1,565	1,565	1,407	1,255

Table 11. Relationship between the quantity of pre-IPO innovation, management quality, and post-IPO operating performance

The sample consists of 1,851 venture-backed IPOs conducted between 1993 and 2004. OIBDA is the ratio of operating income before depreciation plus interest income (Compustat items 13 and 62, respectively) to the book value of total assets (item 6). OIBDA is adjusted for industry performance by subtracting contemporaneous industry (2-digit SIC code) medians. Year 0 is the year of IPO. ΔOBIDA -1 to 0, ΔOBIDA -1 to 1, ΔOBIDA -1 to 2 and ΔOBIDA -1 to 3 are the changes in post-issue operating income from year -1 to year 0, 1, 2, and 3, respectively. LNCOUNTPRE is the natural logarithms of one plus COUNTPRE. COUNTPRE is the number of patents a firm files for and is eventually granted in pre-IPO years -1 and -2 combined. MQFDUMMY is a binary variable that takes a value of one for firms with above median MQF score and zero otherwise. Q1 is a dummy variable which takes a value of one for firms with above MQF score and above median number of patents a firm files for and eventually is granted in in pre-IPO years -1 and -2 combined, and zero otherwise. LNRESCOUNT is the residuals from regressions of LNCOUNTPRE on MQFDUMMY, TENURE, and TENHET. LNRESCOUNT×MQF is the interaction of LNRESCOUNT and MQFDUMMY. TENURE is the average number of years a firm's management team members have been with the firm. TENHET is the coefficient of variation of the management team members' tenures. LNSIZE is the natural logarithm of the book value of assets immediately prior to the IPO. LNAGE is the firm age defined as the natural logarithm of one plus the firm age. ODIR is the proportion of outside directors in the board of directors. INSIDERA is the proportion of voting power owned by firm officers and directors immediately after the IPO. BOSS is an indicator variable equal to one if a CEO is also a Chairman of the board of directors, and zero otherwise. INSTP is the percentage of institutional stock holdings immediately after the IPO. RDASSETS is R&D expenses scaled by firm assets in the IPO year. CAPEXASSETS is capital expenditure scaled by firm assets in the IPO year. ROA is net income scaled by firm assets in the IPO year. All regressions include industry dummies. Standard errors are clustered at industry-level. Standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variables	ΔOIBDA -1 to 0	ΔOIBDA -1 to 1	ΔOIBDA -1 to 2	ΔOIBDA -1 to 3	ΔOIBDA -1 to 0	ΔOIBDA -1 to 1	ΔOIBDA -1 to 2	ΔOIBDA -1 to 3
Constant	0.297	0.161	0.300	0.275	0.507	0.180	0.159	0.282
	(0.359)	(0.403)	(0.392)	(0.433)	(0.353)	(0.392)	(0.375)	(0.424)
Q1	0.114***	0.127***	0.119***	0.095**				
	(0.027)	(0.032)	(0.032)	(0.037)				
LNRESCOUNT×MQF					0.040	0.055*	0.048	0.021
					(0.028)	(0.032)	(0.031)	(0.037)
LNRESCOUNT					0.009	0.013	0.015	0.008
					(0.023)	(0.026)	(0.025)	(0.030)
MQFDUMMY					0.036**	0.044**	0.044**	0.051**
					(0.016)	(0.018)	(0.019)	(0.022)
TENURE	-0.005*	-0.003	-0.001	-0.003	-0.004	-0.001	-0.001	-0.003
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)
TENHET	0.005	-0.004	0.007	0.007	0.005	-0.002	0.005	0.008
	(0.010)	(0.011)	(0.011)	(0.013)	(0.010)	(0.011)	(0.011)	(0.012)
LNSIZE	-0.022***	-0.011	-0.010	-0.012	-0.019***	-0.013	-0.010	-0.014
	(0.007)	(0.008)	(0.008)	(0.009)	(0.007)	(0.008)	(0.008)	(0.009)
LNAGE	-0.014	-0.006	-0.013	-0.017	-0.028*	-0.018	-0.014	-0.017
	(0.013)	(0.016)	(0.016)	(0.019)	(0.015)	(0.017)	(0.017)	(0.020)
ODIR	0.138***	0.150***	0.115**	0.139**	0.125***	0.147***	0.092*	0.109*
	(0.047)	(0.055)	(0.056)	(0.065)	(0.048)	(0.054)	(0.054)	(0.064)
INSIDERA	-0.033	-0.001	-0.017	-0.049	-0.041	0.006	-0.013	-0.064
	(0.041)	(0.048)	(0.050)	(0.057)	(0.041)	(0.047)	(0.048)	(0.056)
BOSS	-0.010	-0.003	-0.004	-0.007	-0.008	-0.008	-0.003	0.002
	(0.016)	(0.019)	(0.020)	(0.023)	(0.016)	(0.019)	(0.019)	(0.022)
INSTP	-0.003	0.035	-0.002	0.020	-0.003	0.015	0.020	0.033
	(0.055)	(0.065)	(0.066)	(0.077)	(0.057)	(0.064)	(0.064)	(0.076)
RDASSETS	0.065	-0.090	0.004	0.023	0.050	-0.120	-0.040	-0.094
	(0.077)	(0.091)	(0.093)	(0.106)	(0.078)	(0.088)	(0.089)	(0.104)
CAPEXASSETS	-0.274**	-0.194	-0.080	-0.006	-0.278**	-0.254*	-0.108	-0.029
	(0.115)	(0.138)	(0.140)	(0.159)	(0.118)	(0.136)	(0.136)	(0.158)
ROA	-0.293***	-0.375***	-0.602***	-0.650***	-0.292***	-0.380***	-0.610***	-0.696***
	(0.033)	(0.042)	(0.045)	(0.051)	(0.034)	(0.042)	(0.044)	(0.052)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1763	1622	1450	1291	1702	1565	1407	1255