Stock Market Overvaluation, Moon Shots, and Corporate Innovation

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We test how market overvaluation affects corporate innovation. Estimated stock overvaluation is very strongly associated with R&D, innovative output, and measures of innovative novelty, originality, and scope. R&D is much more sensitive than capital investment to overvaluation. Misvaluation affects R&D more via a non-equity channel than via equity issuance. We document how the sensitivity of R&D and innovative outcomes to misvaluation depends on growth, overvaluation, and turnover. The frequency of exceptionally high innovative inputs/outputs increases with overvaluation. This evidence suggests that market overvaluation may generate social value by increasing innovative output and by encouraging firms to engage in 'moon shots.'

Keywords: stock market misvaluation, innovation, R&D, patents, behavioral finance, market efficiency

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1. Introduction

Both efficient and inefficient market theories imply that higher stock prices will be associated with higher corporate investment. This includes both the creation of tangible assets through capital expenditures, and the creation of intangible assets through research and development (R&D). Under the Q-theory of investment (Tobin 1969), higher stock price accurately reflects stronger growth opportunities, so high valuation firms invest more to exploit better opportunities. If the incremental investment of a high-valuation firm is for innovative purposes, as reflected in R&D expenditures, the firm should achieve greater innovative output, in the form of new discoveries, techniques, or products.

Similar effects arise when markets are inefficient and investors misvalue different firms differently. Under what we call the *misvaluation hypothesis of innovation*, firms respond to market overvaluation by engaging more heavily in innovative activities, resulting in higher future innovative output. It further maintains that overvaluation encourages more risky and creative forms of innovation.

One way that equity overvaluation can stimulate investment is by encouraging the firm to raise more equity capital (Stein 1996; Baker, Stein, and Wurgler 2003; Gilchrist, Himmelberg, and Huberman 2005) to exploit new shareholders.[1] If firms are inclined to invest the additional funds, overvaluation encourages investment. For example, if the market overvalues a firm's new investment opportunities, the firm may commit to additional investment in order to obtain favorable terms for new equity (or risky debt) financing.

[1] Several authors provide evidence suggesting that firms time new equity issues to exploit market misvaluation, or manage earnings to incite such misvaluation—see, e.g., Ritter (1991), Loughran and Ritter (1995), Teoh, Welch, and Wong (1998a, 1998b), Teoh, Wong, and Rao (1998), Baker and Wurgler (2000), Henderson, Jegadeesh, and Weisbach (2006) and Dong, Hirshleifer, and Teoh (2012). There is also evidence that overvaluation is associated with greater use of equity as a means of payment in takeovers (Dong et al. 2006), as predicted by the behavioral model of Shleifer and Vishny (2003).

There are pathways other than the financing channel by which overvaluation can affect innovation. For example, managers of an overvalued firm may feel insulated from board or takeover discipline, and therefore may be more willing to undertake risky innovative activity—a governance channel. Managers who desire publicity may also be attracted to ambitious, glamorous and attention-grabbing projects.

There is also a possible catering channel. Managers who prefer high current stock prices may spend heavily, even at the expense of long-term value, to cater to investor optimism about those investment opportunities that investors find appealing (Stein 1996; Jensen 2005; Polk and Sapienza 2009). We expect such incentives to be especially strong for innovative spending, as innovative activities are exciting to investors and especially hard for the market to value. Current overvaluation may be an indicator that such catering is likely to be effective. Also, managers may be motivated to maintain high stock prices (Jensen 2005), possibly in part because high prices serve as a reference point for investor perceptions (Baker, Pan, and Wurgler 2012; Li and Yu 2012; George, Hwang, and Li 2017).

Two other behavioral mechanisms can also induce an association between misvaluation and innovative activity. Managers themselves may share in the positive sentiment of investors that is the source of overvaluation. If, for example, managers overestimate innovative growth opportunities, the firm will undertake more such activity. Second, managers may be rationally cognizant of overvaluation, but the positive sentiment of consumers, suppliers or potential employees may improve the firm's opportunities in factor and product markets, making innovative activity more profitable. This positive feedback effect is modeled, for example, in Hirshleifer, Subramanyam, and Titman (2006). We refer to these two mechanisms as shared sentiment effects.

These considerations motivate testing whether misvaluation predicts innovative input, in the form of R&D expenditures, and innovative output, in the form of patents and patent citations. Understanding how misvaluation affects R&D and resulting innovative output is important, since R&D is a key source of technological innovation (Hall, Jaffe, and Trajtenberg 2005), and is a major component of aggregate corporate investment (higher than capital expenditures since 1997 in our sample).

We also explore how misvaluation affects the *ambitiousness* of firms' innovative activities. When a firm is overvalued, management may have greater freedom to engage in 'moon shot' projects, where we define a moon shot as a risky project involving radical solutions to problems, breakthrough technology, and major scope for improving the welfare of customers. Overvaluation can relax financing constraints on such projects, and can allow an ambitiously innovating firm to maintain a high stock price. Overvaluation can therefore help offset the limiting effect of managerial risk aversion on the riskiest forms of innovation. Indeed, since innovative activities tend to create positive externalities, overvaluation may sometimes be welfare-improving, as suggested by Keynes (1931), Gross (2009) and Shleifer (2000).

We therefore measure both the amount of innovative output—number of patents or patent citations—and the nature of the innovative activity. To evaluate the effects of misvaluation on the nature of innovation, we test whether overvaluation—especially in the extreme—is associated with three aspects of innovativeness defined in previous literature. *Innovative novelty* is the number of citations per patent (Seru 2014). *Innovative originality* is defined as the extent to which a patent cites previous patents spanning a wide range of technology classes; *innovative scope* is the extent to which a patent is cited by future patents spanning a wide range of technology classes (Trajtenberg, Henderson, and Jaffe 1997).[2] We use the term *inventiveness* to refer collectively to these three aspects of innovation; we consider projects with very high expected inventiveness to be moon shots. We illustrate in Section 2 the co-occurrence of overvaluation and innovative activity with the case examples of Tesla, SpaceX, and NetApp.

A key challenge for estimating the relationship between innovative activity or output to misvaluation is that valuation is endogenous; in an efficient market, firms with strong opportunities for innovative investment will rationally have high prices. In consequence, high valuation measures should predict high innovative investment, and subsequently, high innovative output. In other words, there is possible reverse causality. We address this issue by using measures of misvaluation which are designed to exclude or purge, as much as possible, this rational component of valuation. Notably, these two misvaluation proxies are motivated and constructed very differently. We also include additional controls and tests, to act as robustness checks on our conclusions.

The first misvaluation proxy, *VP*, is the ratio of 'intrinsic value' (*V*) to market price *P*. *V* is a forward-looking measure of fundamental value derived from the residual income model of Ohlson (1995) using analyst forecasts of future earnings. A key advantage of *V* as a measure of fundamental value as compared, for example, to book value, is that *V* incorporates earnings growth prospects. As such, it filters such prospects from market price, except insofar as such prospects are associated with misvaluation rather than just growth (as discussed in more depth in

[2] For a given total citation count, greater novelty suggests that a firm's patents are important rather than being 'least publishable units;' see Seru (2014). Regarding originality, a patent that draws upon knowledge from a wide range of technology areas is indicative of an innovation that deviates more from current technological trajectories. Drawing upon diverse technologies may also reflect the firm's ability to recombine technologies in an original way. Previous literature refers to what we call "scope" as "innovative generality." For applications of innovative originality and scope, see also Hall, Jaffe, and Trajtenberg (2001), Lerner, Sørensen, and Strömberg (2011), Custodio, Ferreira, and Matos (2013), and Hirshleifer, Hsu and Li (2017). Section 2 discusses in more depth the motivation for and estimation of the three dimensions of innovation inventiveness.

Section 2).[3]

The second misvaluation measure, *MFFlow*, is not based on market price. This is especially helpful for addressing the abovementioned endogeneity problem, that high price reflects opportunities for innovative investment. *MFFlow* uses mutual fund hypothetical sales of stocks as a function of investor outflows, following Edmans, Goldstein, and Jiang (2012) (building on Coval and Stafford (2007)). These papers find that mutual fund outflows (excluding sector funds) lead to selling pressure on stocks held in the funds, thereby temporarily depressing the prices of fund stock holdings for non-fundamental reasons.

Although both misvaluation proxies are designed to exclude the contaminating effects of growth prospects that are unrelated to misvaluation,[4] as a failsafe we include several controls for such opportunities in all our tests (see Section 3.1). If market participants tend to overvalue firms with good growth prospects, the inclusion of growth controls in our regressions will eliminate some of the misvaluation effect we seek to measure. This leads to conservative inferences. Nevertheless, the effects of misvaluation that we document are strong.

We perform three types of tests. First, we examine how misvaluation affects innovative investment in the form of R&D, and innovative output and inventiveness using patent-related measures. This includes tests of whether misvaluation affects the propensity toward extremes of high innovation. Second, we estimate whether the relation between misvaluation and innovative spending operates more through equity issuance versus other mechanisms, such as shared

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[3] *V* is also invariant with respect to accounting choice, and reduces problems with long-horizon terminal value calculations that are present in discounted cash flow models of fundamental value (Feltham and Ohlson 1995; Cornell 2013). *VP* has been applied in a number of studies to the prediction of subsequent returns (Frankel and Lee 1998; Lee, Myers, and Swaminathan 1999), repurchases (D'Mello and Shroff 2000), takeover-related behaviors (Dong et al. 2006), and new issues (Dong, Hirshleifer, and Teoh 2012).

[4] We do not expect *VP* to be uncorrelated with a firm's growth opportunities, since investors may misvalue such opportunities. Rather, its use of a forward-looking fundamental goes far to filter out a *mechanical* relationship between growth opportunities and *VP*. This is in sharp contrast with other valuation ratios such as book-to-market or Tobin's Q.

sentiment or direct catering to investor misperceptions. Third, to test hypotheses about when misvaluation effects will be most important, we examine how the sensitivity of innovative activities to misvaluation varies with growth opportunities, turnover, and misvaluation itself.

We find that overvaluation has a very strong and robust association with higher intangible investments and resulting outputs (R&D, patents, and patent citations). For example, the sensitivity of R&D to misvaluation (variables scaled by their standard deviations) is much larger than the sensitivity to book-to-price, and is larger or comparable to the sensitivity to growth in sales and cash flow. Furthermore, the sensitivity of R&D to misvaluation is about 4-8 times greater than the sensitivity of capital expenditures to misvaluation using either of our mispricing proxies.[5]

With regard to inventiveness, we find that overvaluation is strongly associated with greater innovative novelty, originality, and scope. The patents of overvalued firms are heavily cited, draw from a wider range of technology classes, and are cited by patents in a greater range of technology classes. So misvaluation affects the qualitative nature, as well as the quantity, of innovative activity.

Furthermore, we find that the relations of misvaluation with innovative inputs, outputs, and inventiveness measures are highly nonlinear, and are especially strong in influencing the extremes of high innovation. OLS regression indicates that the effects of misvaluation on innovative activity measures are especially strong among the most overvalued firms. Quantile regression further indicates that variation in misvaluation has an especially strong effect in increasing the frequency of unusually high innovative outcomes. Collectively, these findings

[5]A previous literature examines the effects of misvaluation on equity issuance and on capital expenditures. With respect to R&D, Polk and Sapienza (2009) use the firm characteristic of high versus low R&D as a conditioning variable in some of their tests of the relation between misvaluation and capital expenditures. Baker, Stein, and Wurgler (2003) examine several measures of investment, one of which is the sum of capital expenditures and R&D, but do not examine whether misvaluation affects capital expenditures and R&D differently.

indicate that overvaluation—especially high overvaluation, encourages firms to engage in moon shot projects in the sense of very high inventiveness and expected innovative output.

The strong convexity of misvaluation effects also suggests that as misvaluation fluctuates, these effects do not just average out. Owing to Jensen's inequality, the stochastic occurrence of under- and overvaluation may on average increase innovative activity and inventiveness, potentially increasing welfare.[6]

The potentially positive effect of overvaluation on innovation contrasts with the adverse effects of overvaluation in inducing questionable capital expenditures (Polk and Sapienza 2009) and acquisitions (Dong et al. 2006). Although we cannot know whether the benefits of higher innovation are worth the cost, these findings reinforce other evidence that behavioral biases, such as managerial overconfidence, sometimes promote innovation (Hirshleifer, Low, and Teoh 2012).

To assess the relative importance of equity-financing versus other channels through which misvaluation can affect innovation, we conduct a path analysis of the R&D and capital expenditure responses to misvaluation; see Baderstcher, Shanthikumar and Teoh (2017). Using either of our misvaluation proxies, we find over two thirds of the total effect of misvaluation on both R&D and capital spending derives from the non-equity channel.

The evidence that overvaluation induces firms to raise cheap equity capital to finance intangible investment is consistent with the models of Stein (1996) and Baker, Stein, and Wurgler (2003). The evidence that misvaluation effects operate outside the equity channel is consistent with both the catering theory of Jensen (2005) and Polk and Sapienza (2009), and with the shared sentiment effects discussed above. The larger magnitudes of the non-equity channel

[6] In discussing what he viewed as a period of overvaluation by many firms, Keynes (1931) wrote that "[w]hile some part of the investment which was going on … was doubtless ill judged and unfruitful, there can, I think, be no doubt that the world was enormously enriched by the constructions of the quinquennium from 1925 to 1929..."

suggest that catering and/or shared sentiment effects of misvaluation may be particularly strong.

With regard to the third issue, we dig more deeply into the misvaluation effect by considering interactors which, under different hypotheses, should strengthen or weaken the sensitivities of innovative spending and outcomes to misvaluation. We interact our misvaluation measures with indicators for firms in the highest quintile for growth opportunities, equity catering pressure as proxied by share turnover, or (as already mentioned earlier) overvaluation itself.

We find that R&D spending, innovative output, and the three types of innovative inventiveness are more strongly positively associated with overvaluation among growth firms. This is consistent with several theories of the linkage between misvaluation and innovation. For example, overvalued firms can more persuasively cater to investors via R&D, or issue equity to finance R&D, when they have good growth prospects, and shared sentiment of managers and markets is likely to be more extreme when firms have strong growth opportunities. Adjustment costs can also cause investment (potentially including R&D) to be more sensitive to misvaluation among growth firms (van Binsbergen and Opp 2017). This evidence is also consistent with the idea that the greater innovative expenditure of overvalued growth firms results in commensurate innovative output; and that the effects of misvaluation on inventiveness are especially important among growth firms.

Polk and Sapienza (2009) propose that the sensitivity of investment to misvaluation should be higher when managers have a stronger focus on short-run stock prices, as proxied by share turnover, because undertaking an overvalued project can temporarily increase stock price. We find that the sensitivity of innovative output and inventiveness to misvaluation is greatest in the top turnover quintile. This is not the case for the sensitivity of R&D to misvaluation. These findings suggest that greater catering to investor misperceptions or high sentiment among high turnover firms takes the form of undertaking more inventive ('moon shot') projects rather than by increasing R&D.

Finally, we expect misvaluation effects on innovation to be nonlinear, with the strongest marginal effects on innovation occurring among the most overvalued firms. Fixed costs of issuing equity, lumpy investment projects, within-firm knowledge spill-overs, and positive network externalities in innovation all imply convexity in the relation of innovative activities and outputs to misvaluation (see Section 2.4 for details). Consistent with this hypothesis, we find that R&D, innovative output, and inventiveness are *far* more sensitive to misvaluation in the top overvaluation quintile. For example, the effect of overvaluation on novelty, originality or scope is 4-7 times greater within the most overvalued quintile than in the full sample. In other words, extreme overvaluation is associated with 'moon shots'—projects that are exceptionally innovative.

A previous literature tests whether market valuations, or proxies for misvaluation, affect investment by examining whether these have incremental predictive power after controlling for proxies for the quality of growth opportunities.[7] Most of these studies are focused on capital expenditures rather than innovative activity, and earlier tests do not distinguish the Q-theory of investment from the misvaluation hypothesis. Our approach differs from these papers in focusing on misvaluation effects on *innovation*, including *innovative outcomes*; and in our measures of misvaluation. We compare our misvaluation proxies to others used in previous literature in Section 2 in the discussion that includes footnote 16. Finally, a large literature investigates the economic factors that drive innovation (see, e.g., Acharya and Xu (2017) and references therein).

[7] See Barro (1990), Blanchard, Rhee, and Summers (1993) Morck, Shleifer, and Vishny (1990), Welch and Wessels (2000), Baker, Stein, and Wurgler (2003), Gilchrist, Himmelberg, and Huberman (2005), Polk and Sapienza (2009), Hau and Lai (2013), Parise (2013), Alti and Tetlock (2014), and Warusawitharana and Whited (2015).

Building on this research, our paper additionally describes how market misvaluation affects innovation.

2. Data, Empirical Measures and Test Design

Our sample includes U.S. firms listed on NYSE, AMEX, or NASDAQ that are covered by CRSP and COMPUSTAT and are subject to the following restrictions. We require firms to have the earnings forecast data from I/B/E/S, in addition to possessing the necessary accounting items, for the calculation of the residual income model value to price (*VP*) ratio. Consequently, our sample starts from 1976 when I/B/E/S reporting begins. We also construct mutual fund flows measure (*MFFlow*) from CDA/Spectrum and CRSP. Finally, we exclude financial firms (firms with one-digit SIC of 6) and utility firms (two-digit SIC of 49). Our final sample has 63,724 total firm-year observations with non-missing equity misvaluation measures from 1976 to 2012.

We examine the relation between firm innovation (innovative input as measured by R&D, and innovative output and inventiveness variables described below) and the misvaluation level of the firm's equity. We relate a firm's innovation activity during each fiscal year to the firm's misvaluation measure calculated at the end of the preceding fiscal year. For example, for a firm with December fiscal year end, the misvaluation measure is calculated at the end of December 2010 and the innovation activity is measured for the fiscal year ending in December 2011. Our sample includes firms with different fiscal year-ends.

2.1 Measures of Innovative Output and Inventiveness

Patent and citation data are constructed from the November 2011 edition of the patent database of Kogan, Papanikolaou, Seru, and Stoffman (see Kogan et al. 2016). This database covers U.S. patent grants and patent citations up to 2010. On average, there is a two-year lag between patent application and patent grant. Since the latest year in the database is 2010, we end our observations of patents and citations in 2008 to reduce measurement bias caused by the application-grant period lag.

Following the innovation literature, we use two measures of innovative output. The first and simplest measure is the number of patents successfully applied for in a fiscal year (*Pat*); we count the patents in the application year and the grant may occur subsequent to the application fiscal year. However, simple patent counts imperfectly capture innovation success as patent innovations vary widely in their technological and economic importance. Following Hall, Jaffe, and Trajtenberg (2001, 2005)), we measure the importance of patents by their citation counts *Cites*, measured as the sum of raw citation counts received by patents applied for each year, scaled by the average citation counts of all patents applied in the same year and technology class. In our regression tests, we use log transformed values of *Pat* and *Cites* to limit the effects of extreme outliers.

We use three measures of innovative inventiveness based on patent and citation outcomes. Following Seru (2014), *Novelty* is the average (technological class and year adjusted) citations per patent that are received over time (including subsequent years). It is a natural way to capture the importance of the innovations generated by the firm.

Following Trajtenberg, Henderson, and Jaffe (1997), we define *Originality* of a patent as one minus the Herfindahl concentration index for the fraction of citations made by the patent to patents in other technological classes. If a patent cites previous patents that span a wide (narrow) set of technologies, the originality score will be high (low). This is based on the idea that innovation is a process of recombinant search (e.g., Schumpeter 1934; Basalla 1988; Romer 1990; Weitzman 1998; Singh and Fleming 2010). Under this view, useful new ideas come from combining existing ones in novel ways. An example is the discovery of the double helix structure of DNA by James Watson and Francis Crick. Crick's knowledge of X-ray crystallography helped Watson understand the famous X-ray diffraction image of DNA as a double helix structure.

Also following Trajtenberg, Henderson, and Jaffe (1997), *Scope* of a patent is defined as one minus the Herfindahl index across technological classes of future citations of the patent. This reflects the extent to which a patent has a wide influence. It is a natural way of measuring the extent to which an innovation is broad in scope, making it is useful in a wide range of different technological applications. Each of the three inventiveness measures is firm-level average over the patents' respective inventiveness scores. The innovative output (*Pat* and *Cites*) and inventiveness (*Novelty*, *Originality*, and *Generality*) measures are for a given patent application year and so include the grant and citations received subsequent to the application year. This allows for the lags between patent application, patent granting, and patent citations.

Tesla and SpaceX, founded by celebrity entrepreneur Elon Musk, are two current examples (outside our sample period) of possible irrational investor enthusiasm promoting moon shot innovation.[8] Tesla aims to disrupt the automobile industry with electric vehicles affordable to the average consumer. Cornell and Damodoran (2014) and Cornell (2016) perform case valuation analyses of the approximately 7-fold run-up in Tesla during a period of under a year during 2013-14, and conclude that this is hard to justify as a rational response to news.

SpaceX, although not literally in the business of moon shots, comes close, as its purpose is to monetize space travel, with a long-term goal of colonization of Mars. SpaceX is a private firm valued at $21 billion as of 10/16/17 (Sorkin 2017). Gornall and Strebulaev (2017) point out

[8] NetApp, a multinational storage and data management company, is an example within our sample. Just prior to fiscal year 2000, NetApp had a very low *VP*, and other indications of overvaluation such as heavy recent equity issuance. In fiscal 2000, it ranked in the top quintile in our sample for R&D, patents, patent citations, and in the patent-based measures of inventiveness that we examine.

that the valuations of many unicorns such as SpaceX are grossly inflated owing to valuations being based upon recently-issued shares with special cash flow rights.[9]

2.2 Investment and Control Variables

We measure firms' investment activities using the research and development (XRD) and capital expenditure (CAPX) items from the COMPUSTAT annual files. Our investment variables, *RD* and *CAPX*, are scaled by previous year total assets (item AT). All ratio variables, include the ones described below, are winsorized at the 1st and 99th percentile to mitigate the influence of outliers. Table 1 reports summary statistics of the investment and innovation variables.

We need equity issuance to examine the equity channel of the effect of misvaluation on investment. Following Baker and Wurgler (2002), equity issuance (*EI*) is calculated as [ΔBook Equity (COMPUSTAT item CEQ) + ΔDeferred Taxes (item TXDB) − ΔRetained Earnings (item RE)] scaled by lagged assets. This is a net issuance variable.

In the multivariate tests, we control for other investment determinants. These control variables include growth rate in sales in the past three years (*GS*), cash flow [item IB + item DP + item XRD] scaled by lagged assets [missing XRD is set to zero], to control for the ability of the firm to generate cash from operations to fund investment. We include leverage (*Leverage*) defined as (item DLTT + item DLC)/(item DLTT + item DLC + item SEQ). Finally, we control for firm age and size (lagged total assets) per DeAngelo, DeAngelo, and Stulz's (2010) finding that mature firms are less likely to issue new equity. Following DeAngelo, DeAngelo, and Stulz

[9] Since these 'valuations' are not based on market prices for common shares, such 'overvaluation' need not imply any investor misperception. However, it almost surely does. It is common for managers and other employees in innovative start-ups to receive option compensation for their efforts, and these investors typically lack the financial sophistication needed to adjust reported firm valuations for subtle biases. Indeed, according to Strebulaev, "These financial structures and their valuation implications can be confusing and are grossly misunderstood not just by outsiders, but even by sophisticated insiders." Strebulaev also points out that "SpaceX's value actually fell in 2008" during a period when its reported valuation increased (Sorkin 2017).

(2010), we define *Age* as the number of years between the listing date and the beginning of the fiscal year, truncated at 50 (results are not sensitive to this truncation). Summary statistics of these control variables are reported in Table 1.

2.3 Mispricing Proxies

We use two misvaluation proxies. *VP* is the ratio of fundamental value to price, and *MFFlow* is the mutual fund outflow price pressure measure; further details about these two measures of misvaluation, which are drawn from previous literature, are provided in the Appendix A and B respectively.

The residual income value *V* is estimated as the sum of book value of equity, the discounted analyst forecasted earnings derived from the firm's equity in the next two years in excess of the firm's cost of equity capital, and the analyst forecasted earnings derived from the firm's equity in the third year in excess of the firm's cost of equity discounted as a perpetuity, where the discount rate is the firm's cost of equity.[10] Book equity is measured at the end of the prior fiscal year, and negative observations are deleted. Lee, Myers, and Swaminathan (1999) report that the quality of their *V* estimates is not sensitive to the choice of forecast horizon beyond three years. The predictive ability of *VP* has been found to be robust to alternative cost of capital models (Lee, Myers, and Swaminathan 1999) and to whether the discount rate is allowed to vary across firms (D'Mello and Shroff 2000).[11]

Dong et al. (2006), Dong, Hirshleifer and Teoh (2012) provide more detailed motivation

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[10] In unreported robustness tests we estimate *V* using a 5-year rather than 3-year forecast period. Many firms have missing EPS forecasts beyond forecast year 3; to preserve sample size, when the 4-year and 5-year EPS forecasts are missing, we use the 3-year EPS forecast multiplied by the long-run growth forecast rate as a proxy. Our results are highly robust, with only slightly reduced magnitude of the effects.

[11] The present value of residual incomes beyond year three is captured in the terminal value. The value in the residual income model is less sensitive to errors in terminal value estimates than in dividend or cash flow discounting models. For example, D'Mello and Shroff (2000) found that in their sample of repurchasing firms, firms' terminal value was on average 11% of their total residual income value, whereas using a dividend discount model the terminal value was 58% of total value.

for our choice of *VP* as the misvaluation proxy over other measures. There is strong support for *VP* as an indicator of mispricing. It is a stronger return predictor than *BP* (Lee, Myers, and Swaminathan 1999, Frankel and Lee 1998, Ali, Hwang, and Trombley 2003). *VP* is a ratio of equity rather than total asset misvaluation, and equity misvaluation rather than total misvaluation is more likely to matter for innovation spending decisions. Because R&D spending is not a tangible investment that can be used as collateral for borrowing, it is more likely to be funded from equity than from debt.

The residual income value also has several important advantages over book value as a fundamental measure. It is designed to be invariant to accounting treatments (to the extent that the 'clean surplus' accounting identity obtains; see Ohlson (1995)), making *VP* less sensitive to such choices. Crucially, unlike *BP*, *VP* does not have a mechanical relation with R&D. Accounting rules require expensing R&D, which reduces book values, but the market capitalizes the R&D so that high R&D firms tend to have low *BP*. In contrast, since *V* incorporates analyst forecasts of future earnings, *V* reflects the future-profit-creation side of R&D expenditures, not just the expense side.

Furthermore, since *V*, like market price and unlike book value, reflects future growth prospects, the *VP* ratio filters out growth effects contained in *BP* that are unrelated to mispricing. If market participants overvalue firms with good growth prospects, *VP* is designed to capture that misvaluation, and therefore can be correlated with growth prospects. However, unlike *BP*, *VP* is not mechanically increased by the sheer fact that a firm is growing (i.e., that the market foresees increasing future profits). In our sample, the correlation of *BP* with *VP* is fairly low, 0.22. This is to be expected, as much of the variation in book-to-price arises from differences in growth prospects or in managerial discipline that do not necessarily correspond to misvaluation.

It is possible that not all mechanical growth effects are successfully filtered from *VP*. If this problem were severe we would expect our measure to have a high absolute correlation with *Q*. In our sample, the correlation with *Q* is not especially strong (−0.28). We include *BP*, sales growth, or analyst long-term earnings growth forecasts as controls to soak up possible remaining growth effects to focus on the component of misvaluation that is unrelated to growth.

The second misvaluation measure, *MFFlow*, is derived from mutual fund outflows (Coval and Stafford 2007; Edmans, Jiang, and Goldstein 2012). The motivation for this measure is that outflows put immediate pressure on fund managers to sell the underlying fund holdings to meet redemptions, causing temporary downward price pressure on the stocks held within the fund. To ensure that the outflow measure is unrelated to fund manager's private information about the underlying securities, Edmans, Jiang, and Goldstein (2012) refine the measure of Coval and Stafford (2007) by focusing on the *hypothetical* trades made by a fund assuming it sells in equal proportion to its current holdings. Appendix B details the calculation of *MFFlow*.

In validation of their proxy, Edmans, Jiang, and Goldstein (2012) find that stocks with large mutual fund outflows have lower contemporaneous stock returns, and that these low returns are later reversed. The effects are substantial, as discussed below. So a larger outflow indicates greater undervaluation of stocks held by the fund. Inflows are more likely than outflows to reflect private information if fund managers wait to allocate inflows to stocks that they believe have better prospects.[12] We therefore follow Edmans, Jiang, and Goldstein (2012) and include outflows only.[13]

[12] Several studies, such as Jeng, Metrick, and Zeckhauser (2003) and Lakonishok and Lee (2001) find that insider buying reflects private information but insider selling does not, and even recent work that identifies information in insider selling (Ali and Hirshleifer 2017) finds that buying is much more informative. Furthermore, individual investors are more likely to buy attention-grabbing stocks than sell such stocks (Barber and Odean 2008), consistent with the tendency of buying triggered by viewpoint-changing events.

[13] Several other papers employ mutual fund price pressure measure in studying the relationship between misvaluation and investment (e.g., Hau and Lai 2013; Parise 2013; Camanho 2015; Dessaint et al. 2018; Lou and

MFFlow exerts a downward *shock* to misvaluation that is greater for some firms than others, but this does not mean that all firms with an *MFFlow* shock are undervalued. *MFFlow* shifts the distribution of misvaluation across firms by making overvalued firms less overvalued, and making undervalued firms more undervalued. Firms with low *MFFlow* will have a higher distribution of overvaluation (in the sense of First Order Stochastic Dominance) than firms with high *MFFlow*. So crucially, the measure captures variation in misvaluation even within the deep *over*valuation range, not just in the undervaluation range.[14]

As argued in Edmans, Jiang, and Goldstein (2012), the *MFFlow* measure likely reflects an exogenous source of mispricing that is unrelated to firm characteristics such as extent of innovative activity. It is possible in general that fund flows are correlated with news that relates to firms' investment strategies. Edmans, Jiang and Goldstein use hypothetical fund flows to address this potential concern. For example, a firm might have strong growth opportunities, but this does not explain why the funds that hold this firm would receive unusually high inflows. Similarly, an entire industry might have strong investment opportunities, but, following Edmans, Goldstein and Jiang (2012), we exclude funds that specialize in a given industry. Furthermore, in regressions using either *VP* or *MFFlow* as the misvaluation proxy, we also include *BP*, sales growth, or analyst long-term earnings growth forecasts as additional controls for growth.

The premise of the catering hypothesis is that current overvaluation measures are associated with a stronger intention by managers to undertake innovative activities that capture the imagination of investors in order to maintain overvaluation. Several mechanisms can induce

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Wang 2018). Li (2017) also finds evidence supporting the idea that fund flows induce mispricing.

[14] Section 3.4 presents convexity tests where we show that misvaluation effects are strongest for the highest overvalued firms. The results are very similar using either the interaction of *VP* with the lowest *VP* quintile indicator or the interaction of *MFFLOW* with the lowest *MFFLOW* quintile indicator. Since *VP* captures both undervaluation and overvaluation, the similarity in convexity results suggest that the *MFFLOW* measure also captures variations within the overvaluation as well as undervaluation domains.

such an association. First is that overvaluation may reflect overvaluation by investors of the firm's innovative opportunities. A second mechanism is that overvaluation, perhaps induced mechanically via mutual fund flows, causes investors to draw a favorable *inference* about the firm's opportunities from the current stock price. A third mechanism relates to managerial incentives. As argued by Jensen (2005), managers highly value avoiding drops in stock prices, and leading to agency problems of overvalued equity. Specifically, even if current overvaluation is not driven by overvaluation of innovative opportunities, managers may be motivated by high stock prices to develop opportunities that the market is likely to overvalue.

Sentiment that is shared between managers, investors, and stakeholders should also induce a positive association between overvaluation and innovative activity. If both managers and investors overvalue innovative opportunities, the firm will undertake such projects. If stakeholders share this optimism, this makes them more willing to make firm-specific investments, which further increases the benefits to managers of undertaking innovative projects that, for example, benefit from customer or supplier networks. Even if the stock is overvalued for mechanical reasons, such as high *MFFlow* that is unrelated to preexisting overoptimism, managers (and investors) may draw an optimistic inference from the high market price, encouraging innovative activities.

All the mechanisms discussed here relating to catering and shared sentiment are likely to intensify if investors place special attention on unusually high stock prices. Several empirical papers document an investor focus on 52-week highs, and some of these papers provide evidence that this influences managerial behavior.[15]

Some misvaluation proxies used in past studies include discretionary accruals (Polk and Sapienza 2009) and dispersion in analyst forecasts of earnings (Gilchrist, Himmelberg, and

[15] See, e.g., Baker, Pan, and Wurgler (2012), Li and Yu (2012), Birru (2015), and George, Hwang, and Li (2017).

Huberman 2005).[16] The intuitions for these variables are appealing. However, it is also useful to test for misvaluation effects using a more inclusive measure of misvaluation such as *VP,* which is designed to measure the overall misvaluation of the firm's equity rather than the components of misvaluation that derive from earnings management or disagreement; and to perform tests using *MFFlow*, which arguably captures an exogenous shock to misvaluation. More importantly, our paper differs from this previous work in focusing on the effects on innovative inputs, outputs, and inventiveness.

Table 1 reports summary statistics for the two misvaluation proxies as well as *BP*. The benchmark for fair valuation for *BP* and *VP* is not equal to 1. Book is an historical value that does not reflect growth, and residual income model valuations have been found to be too low on average. We retain negative *V* values caused by low earnings forecasts relative to the cost of equity capital, because such cases should also be informative about overvaluation; negative and low values of *VP* indicate overvaluation and large values of *VP* indicate undervaluation. Similarly, to avoid problems with low or zero book value, and for consistency, we also use a *BP* variable rather than *P/B*. Removing negative *VP* observations (about 6% of the sample) tends to

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[16] Morck, Shleifer and Vishny (1990) find that CAPM alpha, their misvaluation proxy, is unrelated to investment. Polk and Sapienza find that discretionary accruals, their misvaluation proxy, is positively related to investment and that the relation is stronger among firms with higher R&D intensity (which are presumably harder to value correctly). Gilchrist, Himmelberg, and Huberman (2005) find that greater dispersion in analyst forecasts of earnings is associated with higher aggregate equity issuance and capital expenditures. Bhagat and Welch (1995) find a weak link between past returns and R&D expenditures among U.S. firms. Using mutual fund fire sales to measure undervaluation, two studies find that undervalued firms cut capital expenditures (Hau and Lai 2013) or R&D (Parise 2013). Baker, Stein, and Wurgler (2003) examine the relation between financial constraints and valuations in determining investment.

Several studies use structural methods to identify misvaluation effects. Chirinko and Schaller (2001, 2012) estimate the relation between aggregate market misvaluation and aggregate corporate investment in the U.S. and Japan. Bakke and Whited (2010) extract investment-relevant information from stock prices and private information and find no evidence that mispricing affects capital investment. In cross-sectional studies, Campello and Graham (2013) decompose Tobin's Q into fundamental and non-fundamental components by regressing Q on accounting performance measures, and compare how capital investment responds to the non-fundamental portion of the stock price between constrained and unconstrained firms during the tech bubble. Alti and Tetlock (2014) find that equity misvaluation influences investment decisions, whereas Warusawitharana and Whited (2015) find that equity misvaluation affects financing but not capital investment.

reduce statistical significance levels in our tests without materially altering the results. *MFFlow* observations are set to be positive reflecting outflows, so the variable is decreasing with overvaluation, just as is *VP*.

When mutual funds have zero or close to zero holdings of a stock, *MFFlow* is mechanically equal to zero. We set *MFFlow* to missing in this case as it has little ability to distinguish degrees of misvaluation among such stocks. Consequently, our measure of *MFFlow* has a considerably stronger price pressure effect than documented in Edmans, Goldstein, and Jiang (2012). For example, the highest-*MFFlow* decile experiences a market-adjusted return of roughly −12% about two quarters after the *MFFlow* measurement. In contrast, Edmans, Goldstein, and Jiang (2012) document a peak price pressure of about −6.5% market-adjusted return for the decile with the highest outflows.

2.4 Conditioning Variables

We expect that the effect of misvaluation on innovation will be stronger among firms with high growth opportunities. For agency reasons, overvalued growth firms may be especially prone to catering investors to maintain a high stock price and raising equity capital to finance investments that investors are overoptimistic about (Jensen 2005). Furthermore, project scale economies should be more relevant to firms with strong potential growth opportunities. When investment is lumpy, the effect of misvaluation on investment is amplified (van Binsbergen and Opp 2017). Our primary measure of growth prospects is the sales growth rate in the past three years (*GS*), but our results are robust to using *BP* or analyst long-term growth forecasts to control for growth.

Polk and Sapienza (2009) provide and test a catering theory in which the investment sensitivity to misvaluation is higher when there is a higher fraction of short-term investors. They document that the sensitivity of capital expenditures to misvaluation is higher for stocks with high share turnover. We measure turnover using monthly trading volume as a percentage of total number of shares outstanding.[17]

Finally, we expect misvaluation to have a stronger marginal effect on innovative investment among overvalued firms (implying an increasing convex relation between investment and overvaluation), for several reasons. First, when there are fixed costs of issuing equity, overvalued firms should be more likely to issue than undervalued firms. A marginal shift in misvaluation does not change the scale of equity issuance for a firm that refrains from issuing equity at all. So among undervalued firms, we expect a relatively small effect on issuance and investment of a reduction in the undervaluation. A similar point holds if projects have a minimum efficient scale. In contrast, when overvaluation is sufficient to induce positive issuance or project adoption, greater overvaluation encourages greater scale of issuance and investment. For example, in the model of van Binsbergen and Opp (2017), investment lumpiness implies that the effect of variations in overvaluation on investment (which potentially includes R&D) is stronger among overvalued than undervalued firms. Alternatively, managers of overvalued firms may be particularly anxious to undertake overvalued investments in order to cater to optimistic investor perceptions (Jensen 2005).

Second, when there are positive complementarities in innovation, overvaluation will tend to have a nonlinear increasing effect on innovation; the sensitivity of innovative spending to incremental valuation is greater when valuation is high, owing to the larger base of innovative activities to build upon, or to the need for a critical mass in the size of the customer or supplier

[17] As is standard, to ensure comparability we divide the NASDAQ trading volume by 2 (LaPlante and Muscarella 1997).

base that is oriented toward the innovation. When such complementarities cross the boundaries of firms, they are called network externalities (Katz and Shapiro 1986). For example, with knowledge spill-over effects, the process of making useful discoveries can contribute to future discoveries across firms.[18]

Finally, when a firm has positive NPV innovative projects with a high probability of failure but also with potential for a big win, risk-averse managers may bypass them for fear of losing their jobs. However, overvaluation, especially extreme overvaluation, can insulate managers from career concerns if such overvaluation is associated with overly favorable assessments of managerial skill. Such overvaluation can therefore encourage undertaking risky innovative projects.

2.5 Time Patterns in Capital Expenditures, R&D and Valuations

Table 2 reports yearly descriptive information for our sample during 1976-2012. Capital expenditures are relatively stable over time, but there is a marked decrease after 2001, suggesting that companies generally cut capital spending after the collapse of the stock market bubble. This decrease in *CAPX* is coupled with a drastic drop in cash flow in 2002 (untabulated). R&D activities, on the other hand, have wider fluctuations but generally increase over time, and decline slightly after 2001. As mentioned in the Introduction, after 1996, *RD* overtakes *CAPX* as the larger component of corporate investment, growing much larger toward the end of the sample period. These facts highlight the importance of studying R&D activity.

Table 2 also shows that overall, the median *VP* (0.57) is higher than the median *BP* (0.45), suggesting, as expected, that residual earnings add value to stocks on average. *VP* has a

[18] It has long been argued that network externalities are a crucial aspect of innovative activity, because building a large enough customer and/or supplier base is often crucial for the viability of an innovation. This is true, to mention just a few examples, of television, telephony, email and social media. This need for a set of relevant suppliers or demanders often leads to externalities across firms.

higher median than *BP* each year in the sample except for the years after the collapse of the technology bubble (most of 2002-2005), and the financial crisis years of 2008-2010. In previous studies, average *VP* is less than one because of measurement error in estimating fundamental value. Evidence discussed earlier that *VP* is a strong positive predictor of future return after standard controls is consistent with variations in *VP* capturing differences in misvaluation, with lower *VP* associated with greater overvaluation.[19] The time-series average percentage deviation from the mean *VP* of the lowest (highest) *VP* quintile is 99.7% (116.0%), indicating substantial variation in valuation across firms.

Past research has explored whether R&D predicts future abnormal returns. The results are somewhat mixed, with some studies findings positive return predictive power and some finding no significant effect. It might seem that such tests provide insight into whether overvaluation encourages innovation. However, the misvaluation hypothesis does not have a clear-cut prediction about whether R&D positively or negatively predicts returns, so such tests do not get at the issues explored in our study.

Specifically, even if, as hypothesized, misvaluation affects R&D, we expect much variation in R&D to derive from other sources, notably including rational managerial responses to growth opportunities. Existing theories suggest that such variation can induce misvaluation. As suggested by Lev and Sougiannis (1996) and formally modelled in (Hirshleifer and Teoh 2003; Hirshleifer, Lim, and Teoh 2011), high R&D firms will be undervalued, if investors form expectations based upon earnings without adjusting for the fact that R&D, an economic investment which generates future cash flows, is expensed. In contrast, as we suggest here, high R&D may derive from overvaluation, and therefore be associated with overvaluation. A general

[19] In unreported tests, we confirm that *VP* strongly and positively predicts future returns in our sample after controlling for variables such as size, *BP*, and momentum.

sample will include both sources of variation in R&D, making the prediction for future returns ambiguous. So whether R&D predicts returns is not a test of whether misvaluation induces innovative activity.

3. Results

We report results of the three types of tests described in the introduction: the relation between misvaluation and innovative input and output measures; a path analysis on the channels through which misvaluation affects innovation; and how several conditioning variables interact with the misvaluation-innovation relations. Finally, to test whether misvaluation affects the propensity toward extremes of high innovation, we perform quantile regressions.

3.1 The Relation between Misvaluation and Innovation Measures

We report the regression test results in Table 3 for misvaluation effects on input and outputs of innovative activity and capital expenditures. The dependent variables are the measures of R&D expenditures (*RD*), capital expenditures (*CAPX*), patents (*Log(1+Pat)*), and citations (*Log(1+Cites)*). The independent variables in the regressions include either of the two misvaluation variables (beginning-of-year *VP* or *MFFlow*). The control variables include proxies for growth opportunities (either *BP* or 3 year sales growth *GS*), cash flow (*CF*) measured as net income before depreciation and R&D expense scaled by lagged assets, leverage (*Leverage*), the firm age truncated at 50 (*Age*), and log of lagged assets (*Size*). All independent variables (except for the indicator variables) are standardized to have a mean of zero and standard deviation of one. Following the innovation literature (e.g., Seru 2014; Tian and Wang 2014; Acharya and Xu 2017), we control for year and industry fixed effects using the 2-digit SIC industry classification of Moskowitz and Grinblatt (1999).[20] All standard errors in the regressions are simultaneously clustered by both firm and year.

We report four regression specifications for each dependent variable. Models (1) and (2) use *VP,* while models (3) and (4) use *MFFlow,* as the misvaluation proxy. Models (1) and (3) use the book-to-price ratio (*BP*) as the control for growth opportunities, while models (2) and (4) use the 3-year sales growth rate (*GS*). The use of *BP* as a growth control is likely conservative as it contains information about misvaluation. In subsequent tests, we report results using only *GS* as the growth control; results are also robust using *BP*.

3.1.1 Innovative Input

The first set of columns describes the relationship of misvaluation with R&D. Column 1 shows a highly significant negative coefficient of −2.57 ($t = -14.86$). Since high *VP* indicates equity undervaluation, this finding indicates that greater overvaluation (or less undervaluation) is strongly associated with higher innovative expenditures. A one standard deviation increase in overvaluation is associated with an increase in R&D of over 30% relative to the R&D sample mean. This is greater than the effect of a one standard deviation increase in cash flows, and far stronger than the effect of a one standard deviation decrease in *BP*.[21] Column 2, which uses *GS*

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[20] Past innovation studies generally do not include firm fixed effects, a procedure which has econometric justification. Imai and Kim (2017) observe that "the ability of fixed effects regression models to adjust for unobserved time-invariant confounders come at the expense of dynamic causal relationships between treatment and outcome." For example, in the innovation setting, controlling for firm invariant characteristics, such as managerial overconfidence, employee inventiveness, or consumer/other stakeholder affinity for the firm and its products, is problematic if these characteristics correlate with the firm's ability to exploit misvaluation. Furthermore, firm fixed effects are suitable to remove omitted variable bias arising from unobserved time-invariant confounders, but the relation between innovation and its determinants is likely to be time-varying.

[21] Although not reported, we also perform tests based upon univariate sorts by *VP* and bivariate sorts with *VP* and *BP* to control for growth opportunities. These sorts lead to generally similar conclusions as the regression tests. In particular, when we form 2-way portfolio sorts by *VP* and *BP*, we find R&D is more strongly associated with *VP* than by *BP*. As a specific example, at the beginning of fiscal 2002, Broadcom Inc., a wired and wireless communication device maker, had a *VP* of 0.043 (in the top overvalued quintile of the sample) and a *BP* of 0.578 (in the value category because *BP* was above the sample median in that year). As other signs of stock overvaluation, the

as the control for growth opportunities, indicates a similar sensitivity of R&D to *VP*; the R&D coefficient is −2.46 (t = −12.74). Columns 3 and 4 which use *MFFlow* to misvaluation offer a similar conclusion that R&D spending is positively associated with prior overvaluation, with an economic magnitude roughly comparable to the effects on R&D of growth prospects and cash flow.

One possible interpretation for the negative relation between *VP* and R&D is reverse causality—that investors overvalue firms with high innovation activity. Two considerations help alleviate this concern. First, this argument does not apply in tests that use *MFFlow* to measure misvaluation. Second, there is no evidence in the literature that suggests investors systematically overvalue R&D. To the contrary, since R&D is expensed, it has been argued that investors who are fixated on earnings tend to undervalue firms with high R&D (e.g., Lev and Sougiannis 1996). Furthermore, the evidence that R&D predicts abnormal returns is mixed, and it is, if anything, a *positive* return predictor (e.g., Chan, Lakonishok, and Sougiannis 2001; Eberhart, Maxwell, and Siddique 2004).

We compare these findings with the results for capital expenditures in the next set of columns, to contrast misvaluation effects on intangible investment (R&D) with tangible investment. The effect for R&D is much stronger. For *CAPX* Column 1, capital expenditures are also decreasing with *VP*, but with a much lower magnitude of −0.31 (t = −3.76). The sensitivity of R&D to overvaluation varies from 4.4 times (model 4) to 8.3 times (model 1) that of capital expenditure.[22]

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firm was in the top quintile of equity issuance (relative to lagged assets) in the prior fiscal year and bottom quintile of future 1-year market-adjusted return. It invested 19.7% in R&D as a portion of lagged assets, which is higher than both the cross-sectional meanR&D investment for that year (8.6%) and the firm's capital expenditure (2.1%).

[22] Our findings that the relation of misvaluation to R&D is very different from the misvaluation-CAPX relation indicates that, despite possible accounting discretion in reporting R&D versus capital expenditures, the distinction between the two is economically valid.

One reason misvaluation is more important for innovative spending than for capital expenditures is that, under the misvaluation hypothesis, measured misvaluation is most strongly related to the form of investment that investors are most prone to misvaluing. Intangible investments as measured by R&D have relatively uncertain payoff, which makes them harder to value than projects funded by ordinary capital expenditures.[23] So, intangible projects will tend to present managers with greater opportunities for funding with overvalued equity, and for catering to project misvaluation.

Another reason why misvaluation should have a stronger effect on innovative than routine expenditures is that industry- or market-wide overvaluation can help solve externality problems in innovation; a breakthrough by one firm can open opportunities for other firms. Network externalities in technology adoption and innovation have been emphasized, for example, in Katz and Shapiro (1986), and is a common explanation offered for the rise of centers of innovation such as Silicon Valley.

3.1.2 Innovative Output Measures

We next examine innovative output measures. *Log(1+Pat)* measures the firm's success in obtaining patents; *Log(1+Cites)* indirectly reflects the number and importance of the patents. The regressions again indicate significant misvaluation effects on innovative output using either measure of misvaluation and with alternative controls for growth prospects, suggesting an increase in innovative output that is commensurate with the increased innovative input that is associated with stock overvaluation. A one standard deviation increase in overvaluation (measured by *VP*) leads to a 0.1 increase of *Log(1+Pat)*, which would boost the patent count by 1.53, to 15.09, for a firm with a patent count at the sample mean. This is 11.3% of the sample mean number of patents, which is a more than 30% increase over the sample median patent count of 5 for firms with a positive patent count.[24] A similar calculation suggests that for a firm with the mean *Cites* (12.28), a one standard deviation increase in overvaluation leads to an increase in the year and technology class adjusted citation count of 0.68, which is 5.5% of the sample mean.

Turning to innovative inventiveness, Table 4 shows regressions of innovative novelty, originality, and scope on stock misvaluation. We observe from these regressions that greater overvaluation is also associated with all three proxies for inventiveness. A one standard deviation increase in overvaluation leads to an increase of 14.2%, 11.8%, and 11.1% in *Novelty, Originality,* and *Scope*, respectively, relative to the sample mean values. This suggests that overvalued firms are more prone to engage in 'moon shot' projects.

3.1.3 Robustness

The tests in Tables 3 and 4 are designed to remove the effects of growth opportunities as much as possible to focus sharply on misvaluation effects. Our measures of misvaluation are designed to filter out the component of growth opportunities unrelated to misvaluation (*VP*), or to be exogenous to growth opportunities (*MFFlow*). We also include two growth controls, *BP* or *GS*. As a further control for growth opportunities, in unreported robustness tests we also include analyst long-term earnings growth rate forecast (*LTG*). The requirement of long-term analyst forecast data reduces sample size. Nevertheless, the misvaluation results are robust. In addition, to address the concern that firms acquire innovation through takeovers, we remove all firms involved in acquisition activities in the prior three years; again all of our results remain robust.

[24] For a firm with the mean patent count (13.56), a one standard deviation decrease in *VP* leads to a new *Pat* value *N*, where log(1+*N*) – log(1+13.56) = 0.1. Solving for *N* yields the new patent count of 15.09, which is an increase of 11.3% relative to the sample mean.

The sample for the regressions using R&D is smaller, because R&D is missing in Compustat for many firms. Some studies retain observations with missing R&D and set its value in those cases to zero. A possible problem with this procedure is that some firms may deliberately avoid classifying investment in innovation as R&D to keep their rivals in the dark. In unreported tests, we find that our findings are robust to setting missing R&D values to zero (*VP* and *MFFlow* still significantly affect R&D, though the effects are slightly weaker) or to restricting the sample to non-zero R&D observations (where misvaluation effects on R&D are even stronger).

There are also perceptible differences between the earlier and later periods of our sample. In the earlier years there is a lower level of R&D relative to total assets and higher inflation. In more recent years, many firms hold much higher levels of cash, which could affect the scaling of capital and R&D expenditures. In addition, in later years of the sample, there is a more severe truncation bias in the measurement of citations and inventiveness. In unreported tests, we find that our main findings are robust to splitting the sample into two roughly equal periods or ending the sample much earlier (such as ending in 2000).

Finally, the estimation of *VP* requires I/B/E/S earnings forecast data, which limits our sample to relatively large firms. So, many young and potentially innovative and rapidly growing firms are absent from our sample. When we split the sample into large and small firms based on median total assets, the misvaluation effects on innovation are significant in both samples but stronger among smaller firms. This suggests that the results we document likely understate the misvaluation effects on innovation.

In sum, Tables 3 and 4 suggest that R&D spending is sometimes motivated by overvaluation, not just fundamental business considerations. Jensen (2005) and Polk and

Sapienza (2009) argue that equity overvaluation leads to substantial agency costs in the form of wasteful spending on capital expenditures. Our evidence indicates that the overvaluation effect on investment spending is even stronger for intangible expenditures (R&D) than for tangible capital expenditures. However, overvaluation-driven innovative spending on average converts into higher total innovative output as well as moon shots. Thus, overvaluation can potentially be beneficial for society, especially if more inventive innovations have positive spillover effects.

3.2 Long-Term Effects of Overvaluation on Innovation

It may take some time for the investment in innovation to generate any output, especially relatively fundamental innovations such as moon shot projects. On the other hand, equity overvaluation tends to be transient (e.g., on the order of a few years), and managers may want to take advantage of overvaluation in a timely manner. So it is interesting to look at the long-term effects of overvaluation on innovation.

We therefore examine the long-term overvaluation effects by regressing innovation variables on lagged misvaluation. This repeats the tests in Tables 3 and 4 using lagged misvaluation measures (*VP* or *MFFlow*) by one, two, or three years (hereafter, we use *GS* as a growth control; using *BP* produces similar results). Table 5 reports the results when we lag misvaluation by three years; results using shorter lags follow a similar pattern. For each dependent variable, model (1) uses *VP* and model (2) uses *MFFlow* as the misvaluation proxy. While the misvaluation effect on *RD*, and especially *CAPX,* decreases moving from the immediate next year to three years after, misvaluation significantly predicts future innovative output (*Pat* and *Cites*) and inventiveness (*Novelty*, *Originality* and *Scope*) up to three years ahead, with roughly the same strength as the immediate effect, especially when *MFFlow* is the measure of misvaluation. Therefore, the misvaluation effect on innovation is persistent.

The finding that misvaluation affects long-term investment in innovation is consistent with the catering theory, which is about how transient variations in stock prices motivate managers who care about the short-term prices to take action that affect long-term value. It is also consistent with other corporate finance studies that find enduring effects of misvaluation on corporate policy (e.g., Baker and Wurler (2002) on valuation and capital structure). In addition, the financing channel is influenced by transient mispricing, because, as is well-documented in the corporate finance literature, short-term financial constraints influence long-term investment. Indeed, financing constraints are especially important for R&D activities (Li 2011).

3.3 Equity Financing versus Non-Equity Channels

Misvaluation can affect investment in general, either through equity issuance, risky debt issuance, or via catering or shared sentiment (Stein 1996; Baker, Stein, and Wurgler 2003; Gilchrist, Himmelberg, and Huberman 2005; Jensen 2005; Polk and Sapienza 2009; Badertscher, Shanthikumar and Teoh 2017). (The risky debt financing channel is likely to be minor for innovation companies.) To estimate the extent to which misvaluation affects investment via the equity channel, we perform a path analysis following Badertscher, Shanthikumar, and Teoh (2017). Path analysis is a method of comparing an independent variable's direct effect on the dependent variable to the indirect effects that operate via intermediate variables. However, path analysis does not, in itself, necessarily provide clean identification of causation. We therefore focus on *MFFlow* as misvaluation proxy (even though our results are robust to using *VP* instead) and estimate the following regressions:

$$RD_{it} = a_1 + b_1\, MFFlow_{it} + c_1 EI_{it} + \theta_1\, \mathbf{X}_{1it} + u_{1it}$$

$$EI_{it} = a_2 + b_2\, MFFlow_{it} + \theta_2\, \mathbf{X}_{2it} + u_{2it},$$

where i indexes firms and t denotes years. All regressions include year and 2-digit SIC industry fixed effects in addition to the control variables in the vectors $\boldsymbol{X}_1$ and $\boldsymbol{X}_2$ (such as *GS, CF* or *ROA, Leverage, Age,* and *Size*), with standard errors clustered by firm and year. We conduct a similar path analysis for *CAPX.*

Panels A and B of Table 6 indicate the control variables for each regression. The estimated value of b_1 captures the non-equity effect of *MFFlow* on investment, and the estimated value of $b_2 \times c_1$ captures the effect of *MFFlow* through the equity channel. We interpret the non-equity effect as likely coming from either catering or shared sentiment.

Intuitively, if the relation of equity issuance to investment is similar regardless of whether this issuance was induced by *MFFlow*, the effect of *MFFlow* operating through the equity channel is captured by the corresponding coefficient in the first equation, with the direct effect captured by the *MFFlow* coefficient. The second equation gives the coefficient needed to rescale the *EI* coefficient in the first equation to reflect the sensitivity of the financing variable to *MFFlow*.

Table 6 reports key coefficient estimates from the regressions. The percentages at the bottom of Panel C summarize the portion of the total effect of *MFFlow* that is through the equity issuance versus non-equity channels. The preponderance of the total effect of *MFFlow* on R&D, 76.76%, comes from the non-equity channel. The equity channel contributes the remaining 23.24%. Similarly, most of the effect of *MFFlow* on *CAPX* is through non-equity channel (72.49%) rather than through the equity financing channel (27.51%). Thus, shared sentiment and/or catering effects are slightly more severe for intangible investments. In unreported tests, using *VP* instead of *MFFlow* to measure mispricing, we obtain the same conclusion that non-equity is the primary channel through which stock misvaluation affects corporate investment, especially R&D spending.

3.4 Moon Shots and Convexity of Overvaluation Effects

Table 7 tests for nonlinear effects of overvaluation on innovative investments and output. We test the hypothesis that misvaluation has a stronger marginal effect on innovation among overvalued firms by including an interaction between the *VP* ratio (or *MFFlow*) and an indicator for a firm being in the bottom *VP* or *MFFlow* (top overvaluation) quintile.

Consistent with the hypothesis that misvaluation effects on innovation are convex, the sensitivity of R&D expenditure to *VP* is much stronger among overvalued firms, with a large interaction coefficient of −6.53 ($t = -13.45$). In fact, this relationship only exists within the top overvaluation (bottom *VP*) quintile; the direct coefficient on *VP* is close to zero. Similarly, using *MFFlow* to measure misvaluation, R&D shows a much higher sensitivity to misvaluation in the most overvalued, bottom *MFFlow* quintile, with an interaction coefficient of −4.87 ($t = -8.12$) which is about 5 times larger than the baseline coefficient of −0.96 ($t = -6.49$). A similar conclusion holds for innovative output and inventiveness using either of the misvaluation proxies. In the most overvalued quintile, the effect of overvaluation on innovative output (*Pat* and *Cites*) is 4.5-9.6 times greater, and the effect on inventiveness (*Novelty*, *Originality*, and *Scope*) is 3.9-7.1 times greater, than the baseline effect.

In the full sample, a one standard deviation increase in overvaluation as measured by *VP* leads to an increase of 30% in R&D, 11.3% in patent count, 5.5% in citations, 14.2% in novelty, 11.8% in originality, and 11.1% in scope relative to the sample mean values. However, because of the convexity in overvaluation effects on innovation, the effects are *much* stronger in the top overvaluation quintile. According to the coefficient estimates in Table 7, among the top valuation quintile, a one standard deviation boosts *RD, Pat, Cites, Novelty, Originality,* and *Scope* by 81.4%, 27.8%, 10.2%, 29.3%, 24.5%, and 22.5% relative to the sample mean, respectively. These estimates confirm that when firms are extremely overvalued, overvaluation has an outsized effect that encourages the pursuit of moon shot projects.

Do our *MFFlow* results derive from variation in mispricing within the deep overvaluation range, not just ranges of lower valuations (Section 2.3)? To further get a sense for whether the indicator variable *LowFlow* reflect extreme overvaluation, we use a "cross-interaction" *MFFlow*LowVP* in place of *MFFlow*LowFlow* in the innovation regressions similar to Table 7, and similarly use *VP*LowFlow* instead of *VP*LowVP*. In unreported results, we find that both cross-interaction terms are significantly negative (with lower magnitudes than the original specification, which is not surprising if mixing measures introduces two sources instead of one source of measurement noise) in all innovation regression except *CAPX*. These results provide further confirmation that the effect of *MFFlow* on innovation is higher when firms are extremely overvalued as measured by *VP*; and that the effect of *VP* is stronger when firms are extremely overvalued as measured by *MFFlow*.

3.5 Effects of Growth and Turnover

Tables 8 and 9 describe tests of hypotheses about how growth and turnover affect the relation between misvaluation and innovative activity and output. For each independent variable, model (1) and (2) examine the interaction between misvaluation (measured by *VP* or *MFFlow*) and an indicator for the firm being in the high growth quintile (*HighGS*), and models (3) and (4) address the interaction effect between misvaluation and a high turnover indicator (*HighTurn*).

The R&D columns 1 and 2 show that R&D is more strongly positively associated with overvaluation among growth firms than among other firms. This is consistent with the hypothesis that overvalued firms can more persuasively engage in either catering via R&D, or overvalued equity-financed R&D, when they have good growth prospects. Furthermore, Tables 8 and 9 show that the overvaluation effect on innovative output and inventiveness, are generally stronger among high growth firms. This indicates that the misvaluation-driven high innovative spending converts into fruitful innovative output among firms with high growth prospects.

Polk and Sapienza (2009) propose that the sensitivity of investment to misvaluation should be higher when managers have a stronger focus on short-run stock prices, because undertaking an overvalued project can temporarily increase stock price. Polk and Sapienza use turnover as a proxy for short-term focus by shareholders. The results in Table 8 confirm that the sensitivity of patents and citations to overvaluation is greater among high-turnover firms (top turnover quintile), even though the sensitivity of R&D to misvaluation is not stronger among high-turnover firms. Furthermore, Table 8 shows the sensitivity of innovative novelty, originality and scope to overvaluation is much stronger among high-turnover firms. This is consistent with catering taking the form of undertaking moon shot projects.

In contrast, there is no clear evidence that the effect of overvaluation on capital expenditure is stronger among high growth or high turnover firms; the interaction between misvaluation and *HighGS* or between misvaluation and *HighTurn* is not uniformly significant across the *CAPX* regressions. This is further evidence that overvaluation has a much stronger effect on the creation of intangible assets via R&D than on the creation of tangible assets via capital expenditures.

A possible objection to these interaction tests is that high turnover or growth may themselves be proxies for overvaluation. If so, these tests may be basically similar to the previous results that overvaluation effects are concentrated among the most overvalued firms. To address this possibility, in unreported tests we construct residual *GS* and residual turnover, where residual measures have overvaluation information filtered out. Specifically, we regress *GS* or turnover on misvaluation and misvaluation squared (misvaluation is either *VP* or *MFFlow*), and assign *HighGS* and *HighTurn* based on the residuals. Results continue to hold for innovative output and inventiveness, but the overvaluation effects on R&D (and CAPX) do not show elevated strength among high turnover firms, with some evidence of weaker effects among these firms. A possible interpretation is that catering is mainly done through inventiveness rather than from the amount of R&D. For example, if the market thinks the firm can make game-changing advances, the firm might not increase ordinary product development (the "D" in R&D), or even cut back on it, in order to focus attention on moon shots.[25]

3.6 Effect of Misvaluation on Likelihood of Being an Innovator

Since the majority of firms do not have positive patent and citation counts (Table 1), we also examine whether overvaluation increases the probability that a firm has a positive number of patents, or the likelihood of being an innovator. Logistic regressions (unreported) indicate that overvaluation, especially extreme overvaluation, increases the probability that the firm has a positive patent count. This effect is convex in overvaluation. The interaction between overvaluation and proxies for growth and turnover positively affects the probability that the firm has a positive patent count, consistent with overvaluation increasing the likelihood of being an innovator. Since most firms have zero patents, getting a positive patent count is an indicator of going for a big win. So overvaluation encourages the kind of behavior, which, in the extreme, might be called a moon shot.

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[25] We also performed tests that condition the overvaluation-innovation relationship on financial constraints. Using the Kaplan-Zingales (1997) index to measure financial constraints, we find mixed results (unreported): while overvaluation has a stronger effect on CAPX among constrained firms using this measure (consistent with Baker, Stein, and Wurgler (2003) who argue that misvaluation affects investment through the equity channel which is strong when the firm is constrained), its effect on innovation is stronger among unconstrained firms, possibly because most of the effect on innovation operates through the non-equity channel.

3.7 Quantile Regressions

Our results so far are based on the least squares regressions. We run quantile regressions, which are more robust to influences of outliers and distributional assumptions of the error process than linear regressions, to provide further robustness of our findings.[26] Our purpose is to explore whether overvaluation has an especially strong effect in promoting *unusually* high innovative input, output and inventiveness. For the *RD* and *CAPX* dependent variables, we run quantile regressions for the 0.2, 0.4, 0.6, and 0.8 quantiles of the dependent variable. For *Pat*, *Cites*, *Novelty, Originality*, and *Scope*, since the median is zero, we instead choose quantile values of 0.65, 0.7, 0.75, and 0.8. If overvaluation promotes moon shots---unusually high levels of innovative input, output or inventiveness----then we expect to see stronger overvaluation effects at higher quantiles.

The results are reported in Table 10. For brevity, we only report the coefficients of the misvaluation proxy (*VP* in Panel A and *MFFlow* in Panel B). If overvaluation is especially important in driving the highest R&D outcomes and innovative outputs (moon shots), we ought to observe stronger *VP* (*MFFlow*) effects for higher quantile cutoffs. This is indeed what we observe. For example, for R&D, although the quantile regressions show statistically significant effect of *VP* at all quantiles, the effect of *VP* increases from –0.41 at quantile 0.2 to –2.04 at quantile 0.8, with the difference in *VP* coefficients highly significant. We observe a similar pattern for *CAPX*, although the coefficient estimates are substantially lower than for R&D (e.g., *VP* = –0.53 for quantile 0.8), consistent with our earlier finding that overvaluation has a much

[26] The quantile regression parameter estimates the change in a specified quantile (*Q*) of the response variable produced by a one unit change in the predictor variable. For example, quantile regressions for different *RD* quantiles allow us to compare how some percentiles of *RD* may be more affected by misvaluation than other percentiles using the change in coefficient estimates of misvaluation across the different quantiles.

stronger effect on R&D than on *CAPX*.[27] A similar pattern of increasing absolute magnitude of the regression coefficients for increasing quantiles also holds when *MFFlow* is used as the misvaluation proxy.

In all cases, the effect of misvaluation increases monotonically from lower to higher quantiles, with the difference in misvaluation coefficient between the top and bottom quantiles highly significant for all cases except one ($p = 0.102$ when the dependent variable is *Pat* and the misvaluation proxy is *MFFlow*). These results are therefore consistent with the conclusion that extreme overvaluation especially promotes moon shots in the sense of unusually high innovative investment, output, and inventiveness.

4. Conclusion

We test how market overvaluation affects corporate innovative spending, success, and inventiveness. We use R&D expenditures as a proxy for innovative spending, and patents or patent citations as measures of innovative output and success. We also employ patents-based measures of innovative inventiveness (novelty, originality and scope) from previous literature to evaluate how misvaluation affects the propensity to engage in 'moon shot' projects, and the success of such efforts.

We use two proxies for equity misvaluation that are designed either to remove the effects of growth prospects unrelated to the effects of mispricing, or to focus on variations in mispricing unrelated to growth prospects. Our first proxy is *VP*, the ratio of a residual income valuation, which discounts future earnings to value the firm's equity, to price. The second misvaluation measure uses hypothetical mutual fund outflows, following Edmans, Goldstein, and Jiang

[27] Interestingly, overvaluation also promotes extremes of capital expenditures as well. One interpretation of this is that moonshot innovation sometimes requires capital expenditure as well. Another is that overvaluation induces extremes of investment risk-taking in general, with moonshot innovation being just one example of this phenomenon.

(2012). Extensive additional controls for growth opportunities are also included as a failsafe.

The tests reveal a strong positive association between equity overvaluation and subsequent R&D spending, patent and patent citation production, and inventiveness. These relationships are highly convex, so that within the top overvaluation group, higher overvaluation promotes extremely high innovative activity and inventiveness. Furthermore, even without conditioning on the level of misvaluation, quantile regression indicates that higher valuation (i.e., less undervaluation or greater overvaluation) has an especially strong effect on the frequency of extreme levels of innovative input, output, and inventiveness. In sum, overvaluation promotes 'moon shots.'

The effect of misvaluation operates partly via the association of misvaluation with equity issuance, and more strongly via the non-equity channel, which includes managerial catering to investor optimism about innovation, or alternatively overoptimism that is shared by managers, customers, suppliers, and/or employees as well as investors. Innovative activity and outcomes are more sensitive to misvaluation among growth firms. The sensitivity of innovative outcomes and inventiveness, but not R&D, to misvaluation is also greater among high turnover firms. These outcomes are consistent with catering or shared sentiment effects, especially in the form of taking more inventive projects.

Although each of our measures of misvaluation is imperfect, their ingredients and construction are extremely different. It is therefore notable that the results that come from these two misvaluation measures are extremely similar.

In sum, we find that strong evidence that high overvaluation is associated with greater innovative expenditures that are rewarded with high innovative output, and with a greater propensity of firms to engage in inventive projects. Overvaluation, especially among the most overvalued and catering-sensitive firms, encourages moon shot activities.

There is a natural offsetting between the encouraging effect of overvaluation on innovation and the discouraging effect of undervaluation, since firms are sometimes overvalued and sometimes undervalued. However, our finding of a powerful convexity in the relation of innovative input, output, and inventiveness with misvaluation suggests that the positive effect is likely to predominate. So our findings suggest that ex ante, the possibility of misvaluation increases moon shots and innovation. If, as much research has argued, there are positive externalities in innovative activity, this suggests that the ex ante possibility of strong misvaluation may increase social welfare. This contrasts sharply with the usual presumption that greater market efficiency is welfare improving.

Appendix A. Calculation of Residual Income Value-to-Price (*VP*)

Our estimation procedure for *VP* is similar to that of Lee, Myers, and Swaminathan (1999). For each stock in month *t*, we estimate the residual income model (RIM) price, denoted by *V* (*t*). *VP* is the ratio of *V(t)* to the stock price at the end of month *t*. With the assumption of 'clean surplus' accounting, which states that the change in book value of equity equals earnings minus dividends, the intrinsic value of firm stock can be written as the book value plus the discounted value of an infinite sum of expected residual incomes (see Ohlson (1995)),

$$V(t) = B(t) + \sum_{t=1}^{\infty} \frac{E_t[\{ROE(t+i) - r_e\,(t+i-1)\}B(t+i-1)]}{[1+\ r_e(t)]^i},$$

where *Et* is the expectations operator, *B*(*t*) is the book value of equity at time *t* (negative *B*(*t*) observations are deleted), *ROE*(*t* + *i*) is the return on equity for period *t* + *i*, and *re*(*t*) is the firm's annualized cost of equity capital.

For practical purposes, the above infinite sum needs to be replaced by a finite series of *T* −1 periods, plus an estimate of the terminal value beyond period *T*. This terminal value is estimated by viewing the period *T* residual income as a perpetuity. Lee, Myers, and Swaminathan (1999) report that the quality of their *V* (*t*) estimates was not sensitive to the choice of the forecast horizon beyond three years. Of course, residual income *V* (*t*) cannot perfectly capture growth, so our misvaluation proxy *VP* does not perfectly filter out growth effects. However, since *V* reflects forward-looking earnings forecasts, a large portion of the growth effects contained in *BP* should be filtered out of *VP*.

We use a three-period forecast horizon:

$$V(t) = \frac{[f^{ROE}\,(t+1) - r_e(t)]B(t)}{1 + r_e(t)} + \frac{[f^{ROE}\,(t+2) - r_e(t)]B(t+1)}{[1+r_e(t)]^2} + \frac{[f^{ROE}\,(t+3) - r_e(t)]B(t+2)}{[1+r_e(t)]^2 r_e(t)},$$

where $f^{ROE}(t + i)$ is the forecasted return on equity for period *t* + *i*, the length of a period is one year, and where the last term discounts the period *t* + 3 residual income as a perpetuity.

Forecasted ROE's are computed as

$$f^{ROE}\,(t+i) = \frac{f^{EPS}\,(t+i)}{\bar{B}(t+i-1)},$$

where $\bar{B}(t+i-1)$ is defined as the average of *B* (*t* + *i* −1) and *B* (*t* + *i* −2), and where $f^{EPS}(t+i)$ is the forecasted EPS for period *t* + *i*. If the EPS forecast for any horizon is not available, it is substituted by the EPS forecast for the previous horizon and compounded at the long-term growth rate (as provided by I/B/E/S). If the long-term growth rate is not available from I/B/E/S, the EPS forecast for the first preceding available horizon is used as a surrogate for $f^{EPS}(t + i)$. We require that each of these f^{ROE}'s be less than 1.

Future book values of equity are computed as

$$B(t+i) = B(t+i-1) + (1-k)f^{EPS}(t+i),$$

where k is the dividend payout ratio determined by

$$k = \frac{D(t)}{EPS(t)},$$

and $D(t)$ and $EPS(t)$ are respectively the dividend and EPS for period t. Following Lee, Myers, and Swaminathan (1999), if $k < 0$ (owing to negative EPS), we divide dividends by (0.06 × total assets) to derive an estimate of the payout ratio, i.e., we assume that earnings are on average 6% of total assets. Observations in which the computed k is greater than 1 are deleted from the study.

The annualized cost of equity, $re(t)$, is determined as a firm-specific rate using the CAPM, where the time-t beta is estimated using the trailing five years (or, if there is not enough data, at least two years) of monthly return data. The market risk premium assumed in the CAPM is the average annual premium over the risk-free rate for the CRSP value-weighted index over the preceding 30 years. Any estimate of the CAPM cost of capital that is outside the range of 5%-20% is winsorized to lie at the border of the range. Previous studies have reported that the predictive ability of *VP* was robust to the cost of capital model used (Lee, Myers, and Swaminathan (1999)) and to whether the discount rate was allowed to vary across firms (D'Mello and Shroff (2000)).

Appendix B. Calculation of Mutual Fund Outflow Price Pressure (*MFFlow*)

We follow Edmans, Goldstein and Jiang (2012) to calculate the hypothetical mutual fund outflow price pressure measure. Quarterly mutual fund holdings data are obtained from CDA Spectrum/Thomson and mutual fund returns are from CRSP.

First, in each quarter t, we estimate mutual fund flows for all U.S. funds that are not specialized in a given industry using CRSP mutual funds data as

$$Outflow_{j,t} = \frac{TA_{j,t-1}\left(1 + R_{j,t}\right) - TA_{j,t}}{TA_{j,t-1}},$$

where $TA_{j,t}$ is the total asset value of fund j (= 1, …, m) at the end of quarter t and $R_{j,t}$ is the return of fund j in quarter t, computed by compounding monthly fund returns. $Outflow_{j,t}$ is therefore the total outflow experienced by fund j in quarter t as a percentage of its asset value at the beginning of the quarter.

Second, we calculate the dollar holdings of stock i by fund j at the end of quarter t using data from CDA Spectrum/Thomson. CDA Spectrum/Thomson provides the number of stocks held by all US funds at the end of every quarter. The total dollar value of the participation held by fund j in stock i at the end of quarter t in year t is

$$Share_{i,j,t} \times PRC_{i,t}\,,$$

where $Share_{i,j,t}$ is the number of stocks i held by fund j at the end of quarter t, and $PRC_{i,t}$ is the price of stock i at the end of quarter t.

Third, we compute the quarterly mutual fund flow

$$QMfflow_{i,t} = \sum_{j=1}^{m} \frac{Outflow_{j,t} \times Share_{i,j,t} \times PRC_{i,t}}{VOL_{i,t}},$$

where the summation is only over funds j for which $Outflow_{j,t} \geq 0.05$, and where $VOL_{i,t}$ is the total dollar trading volume of stock i in quarter t. This variable corresponds to the hypothetical selling pressure of stock i by all mutual funds subject to large outflows.

Finally, we calculate the annual *MFFlow* for stock i in quarter t by recursively summing up *QMFFlow* across the four quarters up to quarter t.

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Table 1. Summary Statistics of Innovation Input and Outputs, Valuation, and Control Variables

The sample includes U.S. non-financial firms listed on NYSE, AMEX and NASDAQ with COMPUSTAT and I/B/E/S coverage during 1976-2012. Patent and citation counts data (November 2011 version) is provided by Kogan et al. (2013); we end the patent and citation data in 2008 to reduce truncation biases caused by the delay in patent approval and citation counts. Innovation input is R&D expenditure scaled by lagged total assets (*RD*). Capital expenditures scaled by lagged total assets (*CAPX*) is also reported. Variables for the patents applied for in a fiscal year include: number of patents (*Pat*); number of citations adjusted for the effects of year and technological class (*Cites*); *Novelty* measured by number of citations per patent; *Originality* and *Scope* are patent-citation quality measures as defined by Hall, Jaffe, and Trajtenberg (2001). *VP* is the residual-income-value to price ratio. *MFFlow* is the mutual fund price pressure measure following Edmans, Goldstein, and Jiang (2012). *BP* is the book equity to price ratio. *CF* is cash flow (income before extraordinary items + depreciation + *RD*) over the fiscal year scaled by lagged assets (missing *RD* is set to zero in the *CF* calculation). *Leverage* is defined as (long-term debt + current liabilities)/(long-term debt + current liabilities + shareholders' equity). *Age* is the number of years between the beginning of the fiscal year and the listing date of the firm in CRSP, truncated at 50. *GS* is the growth rate of sales in the 3 years prior to each fiscal year. *LTG* is the long-term analyst earnings growth rate forecast. Equity issuance (*EI*) and debt issuance (*DI*) are equity and debt issuances during the fiscal year constructed from the balance sheet scaled by lagged assets. *Turnover* is monthly trading volume scaled by the number of shares outstanding. Except for the innovation input and output variables, and cash flow (*CF*), and equity issuance (*EI*), which are measured over each fiscal year, all other control variables, valuation variables, and valuation sensitivity variables are measured in the month preceding the beginning of each fiscal year. We choose the most recent fiscal year accounting data available at the end of June each year so that each sample firm appears once for a particular year. Total assets and sales figures are in 2012 dollars. All ratio variables are winsorized at the 1st and 99th percentiles.

	N	Mean	Std Dev	Median	P1	P99
Innovation Input and Output Variables						
RD (%)	40248	8.26	12.33	4.02	0.00	60.53
CAPX (%)	63039	8.03	9.16	5.30	0.21	48.00
Pat	55195	13.56	88.38	0.00	0.00	261.00
Cites	54079	12.28	78.51	0.00	0.00	234.26
Novelty	54079	0.42	0.74	0.00	0.00	3.15
Originality	55115	0.18	0.25	0.00	0.00	0.79
Scope	54079	0.16	0.24	0.00	0.00	0.78
Valuation Variables						
VP	63724	0.63	0.56	0.57	-1.09	2.67
MFFlow (%)	48352	3.19	5.04	1.69	0.01	24.37
Control or Conditioning Variables for Innovation Regressions						
BP	63724	0.63	0.62	0.45	0.03	3.39
GS	55098	0.85	2.19	0.39	-0.63	10.69
CF (%)	63574	12.62	14.84	12.50	-36.41	54.89
Leverage	63724	0.27	0.23	0.24	0.00	0.84
Age	63724	15.02	13.62	10.67	0.42	50.00
Total Assets ($M)	63715	3395.57	18003.86	458.23	17.42	49266.07
LTG	47120	0.18	0.11	0.16	0.04	0.54
EI (%)	63622	7.36	30.06	1.01	-14.64	128.43
DI (%)	63715	7.58	22.64	2.87	-26.98	109.16
Turnover (%)	62482	9.17	10.14	5.69	0.34	48.41

Table 2. Corporate Investment, Innovative Output, and Equity Valuations by Year

This table reports the time pattern of selected variables. The yearly mean values are reported, except for the valuation ratios (*BP* and *VP*) for which the medians are shown. The sample includes U.S. non-financial firms listed on NYSE, AMEX and NASDAQ with COMPUSTAT and I/B/E/S coverage during 1976-2012. Patent and citation data is from Kogan et al. (2016) (November 2011 version); we end the patent and citation data in 2008 to reduce truncation biases.

Year	*N*	*RD* (%)	*CAPX* (%)	*Pat*	*Cites*	*Novelty*	*Originality*	*Scope*	*MFFlow* (%)	*Med. BP*	*Med. VP*
1976	397	3.19	9.47	30.02	28.55	0.62	0.23	0.27		0.78	0.96
1977	537	3.49	10.71	25.20	24.05	0.63	0.21	0.27		0.63	0.83
1978	638	3.44	12.01	21.02	19.82	0.56	0.21	0.24		0.72	0.95
1979	959	3.48	11.82	14.03	13.16	0.52	0.19	0.23		0.79	1.03
1980	1013	3.67	11.61	14.26	13.38	0.49	0.19	0.22		0.75	0.89
1981	1028	3.67	11.57	13.73	13.24	0.51	0.19	0.22	1.27	0.71	0.85
1982	1066	4.01	9.56	12.78	12.31	0.49	0.19	0.22	4.93	0.76	1.07
1983	1168	4.85	8.61	11.06	10.65	0.42	0.17	0.20	4.09	0.65	0.85
1984	1327	5.60	10.57	10.23	10.10	0.43	0.16	0.19	1.42	0.47	0.59
1985	1461	6.09	10.39	9.14	9.31	0.43	0.16	0.19	4.05	0.59	0.95
1986	1429	5.95	9.41	9.82	10.00	0.45	0.17	0.20	4.12	0.54	0.73
1987	1481	5.67	8.99	9.41	9.34	0.42	0.16	0.19	3.80	0.49	0.64
1988	1529	6.12	9.06	9.68	9.70	0.43	0.16	0.19	2.50	0.53	0.72
1989	1518	6.41	8.80	11.35	11.31	0.42	0.16	0.19	1.92	0.52	0.85
1990	1596	6.87	8.66	11.47	11.55	0.44	0.16	0.19	1.47	0.51	0.77
1991	1569	7.10	7.68	11.74	12.06	0.39	0.16	0.19	9.15	0.59	0.84
1992	1678	7.64	7.86	11.29	11.85	0.42	0.16	0.19	2.98	0.46	0.65
1993	1830	8.61	8.76	10.88	11.31	0.43	0.17	0.19	1.88	0.42	0.57
1994	1981	8.98	9.58	11.09	11.73	0.42	0.17	0.18	2.24	0.37	0.56
1995	2209	9.81	9.88	11.99	12.28	0.41	0.17	0.19	1.68	0.41	0.71
1996	2372	9.90	9.83	12.17	12.71	0.41	0.17	0.17	1.95	0.35	0.59
1997	2554	10.84	9.80	13.67	14.18	0.44	0.18	0.18	1.71	0.34	0.49
1998	2637	10.93	9.38	13.65	13.90	0.41	0.18	0.17	2.02	0.32	0.46
1999	2488	10.77	8.18	15.07	15.02	0.42	0.18	0.17	3.94	0.42	0.51
2000	2303	10.89	8.42	17.54	17.36	0.43	0.19	0.16	8.46	0.38	0.45
2001	2242	8.71	6.57	18.76	17.78	0.46	0.21	0.15	4.32	0.41	0.47
2002	2178	9.27	5.33	19.65	17.11	0.47	0.23	0.14	1.41	0.44	0.35
2003	2064	9.16	5.36	20.67	16.23	0.45	0.23	0.12	2.80	0.59	0.56
2004	2070	8.64	5.87	19.15	13.23	0.41	0.22	0.09	2.08	0.37	0.37
2005	2114	8.72	6.16	17.23	10.04	0.37	0.19	0.06	2.12	0.33	0.32
2006	2098	9.68	6.69	14.20	6.57	0.32	0.18	0.04	3.69	0.34	0.35
2007	2076	9.39	7.02	8.69	3.30	0.24	0.16	0.03	2.91	0.34	0.36
2008	2128	8.94	6.46	4.09	1.09	0.15	0.11	0.01	3.15	0.38	0.36
2009	2074	8.90	4.34						3.70	0.72	0.62
2010	1994	8.40	5.22						3.37	0.50	0.45
2011	1963	8.17	6.13						3.03	0.42	0.51
2012	1955	8.64	6.06						3.28	0.49	0.59
All	63724	8.26	8.03	13.56	12.28	0.42	0.18	0.16	3.19	0.45	0.57

Table 3. Regressions of Investments and Innovative Output on Stock Misvaluation

The variables are defined in Table 1. All independent variables are standardized to have a mean of zero and standard deviation of one. All regressions include 2-digit SIC industry fixed effects and year fixed effects. *T*-statistics are reported in parentheses. Standard errors are clustered by firm and year. The sample includes U.S. non-financial, non-utility firms listed on NYSE, AMEX and NASDAQ with COMPUSTAT and I/B/E/S coverage during 1976-2012. The patent and citation (*Pat* and *Cites*) data sample period is 1976-2008.

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	RD				*CAPX*				*Log(1+Pat)*				*Log(1+Cites)*			
VP	-2.57	-2.46			-0.31	-0.42			-0.09	-0.10			-0.04	-0.05		
	(-14.86)	(-12.74)			(-3.76)	(-3.66)			(-5.53)	(-4.95)			(-7.10)	(-5.95)		
MFFlow			-1.35	-1.27			-0.25	-0.29			-0.07	-0.07			-0.03	-0.03
			(-6.75)	(-6.51)			(-3.26)	(-3.37)			(-5.59)	(-5.48)			(-6.21)	(-6.12)
BP	-0.42		-0.72		-1.09		-0.97		-0.05		-0.05		-0.02		-0.02	
	(-2.75)		(-3.73)		(-8.36)		(-7.23)		(-4.02)		(-3.40)		(-3.55)		(-3.30)	
GS		0.88		1.04		0.58		0.54		0.03		0.03		0.02		0.02
		(5.49)		(5.49)		(4.35)		(4.13)		(4.39)		(3.40)		(5.24)		(4.44)
CF	1.35	1.92	1.28	1.87	1.57	2.04	1.50	1.87	0.12	0.17	0.13	0.18	0.05	0.07	0.06	0.08
	(5.50)	(8.62)	(4.86)	(6.90)	(10.34)	(11.64)	(9.85)	(11.55)	(9.49)	(11.67)	(7.76)	(9.91)	(9.60)	(11.72)	(7.84)	(9.89)
Leverage	-1.49	-1.18	-1.60	-1.37	0.70	0.62	0.55	0.51	-0.18	-0.18	-0.22	-0.21	-0.08	-0.08	-0.09	-0.08
	(-13.18)	(-10.78)	(-11.85)	(-10.27)	(7.82)	(6.32)	(6.02)	(5.56)	(-11.58)	(-11.41)	(-11.35)	(-10.85)	(-12.60)	(-12.02)	(-11.87)	(-11.28)
Log(Age)	-0.86	-0.84	-1.44	-1.25	-1.09	-0.75	-0.93	-0.57	0.09	0.19	0.10	0.15	0.04	0.08	0.04	0.06
	(-7.03)	(-5.17)	(-9.23)	(-6.61)	(-10.34)	(-5.11)	(-7.34)	(-3.62)	(5.94)	(6.94)	(4.39)	(4.97)	(5.43)	(6.83)	(3.81)	(4.70)
Size	-2.86	-2.36	-3.33	-2.89	0.11	0.13	0.01	-0.01	0.66	0.69	0.70	0.72	0.24	0.25	0.24	0.25
	(-11.33)	(-10.38)	(-12.14)	(-11.24)	(0.99)	(1.12)	(0.09)	(-0.13)	(19.10)	(19.61)	(17.39)	(17.54)	(20.07)	(20.65)	(18.20)	(18.42)
Intercept	7.19	6.96	7.54	7.32	7.60	7.32	7.26	7.21	-0.13	-0.21	-0.16	-0.19	-0.09	-0.11	-0.08	-0.10
	(38.81)	(51.92)	(47.78)	(49.69)	(35.97)	(36.99)	(36.86)	(33.60)	(-6.88)	(-9.73)	(-6.98)	(-7.48)	(-12.35)	(-14.18)	(-9.47)	(-9.08)
N	40,206	34,658	31,084	27,982	62,954	54,445	47,839	43,253	55,048	47,295	40,692	36,598	53,935	46,296	39,714	35,701
R^2	0.3271	0.3233	0.3135	0.3099	0.1301	0.1275	0.1229	0.1182	0.3909	0.4103	0.3977	0.4109	0.3590	0.3797	0.3648	0.3799

Table 4. Regressions of Innovative Inventiveness on Stock Misvaluation

The variables are defined in Table 1. All independent variables are standardized to have a mean of zero and standard deviation of one. *Novelty*, *Originality*, and *Scope* are in percentage. All regressions include 2-digit SIC industry fixed effects and year fixed effects. *T*-statistics are reported in parentheses. Standard errors are clustered by firm and year. The sample includes U.S. non-financial, non-utility firms listed on NYSE, AMEX and NASDAQ with COMPUSTAT, I/B/E/S, and patent-citation data coverage during 1976-2008.

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Novelty				*Originality*				*Scope*			
VP	-6.13	-5.98			-2.06	-2.12			-1.88	-1.77		
	(-9.54)	(-7.64)			(-7.27)	(-6.21)			(-8.96)	(-6.93)		
MFFlow			-3.53	-3.22			-1.10	-1.08			-1.26	-1.18
			(-5.88)	(-5.87)			(-4.14)	(-4.25)			(-5.83)	(-5.77)
BP	-1.79		-2.83		-0.60		-1.04		-0.34		-0.55	
	(-2.64)		(-3.56)		(-2.11)		(-2.88)		(-1.41)		(-1.69)	
GS		3.18		3.72		0.56		0.77		0.63		0.77
		(5.73)		(5.82)		(3.25)		(3.92)		(3.92)		(4.21)
CF	5.74	7.37	6.10	7.62	1.73	2.31	1.61	2.26	1.87	2.36	1.87	2.34
	(7.87)	(10.41)	(6.87)	(8.81)	(7.51)	(10.44)	(5.35)	(8.29)	(6.89)	(8.06)	(5.44)	(6.66)
Leverage	-7.38	-6.68	-7.84	-7.20	-2.60	-2.47	-3.01	-2.78	-2.72	-2.61	-2.88	-2.67
	(-11.80)	(-10.95)	(-10.96)	(-10.07)	(-11.22)	(-10.55)	(-10.60)	(-9.90)	(-11.91)	(-11.13)	(-10.34)	(-10.12)
Log(Age)	1.24	3.52	-0.01	1.50	1.63	2.66	1.57	2.21	1.41	2.51	1.38	1.92
	(1.50)	(3.33)	(-0.01)	(1.31)	(5.98)	(6.55)	(3.84)	(4.55)	(4.91)	(6.34)	(3.49)	(4.46)
Size	12.76	12.85	12.32	12.70	5.28	5.26	5.23	5.28	4.87	4.79	4.46	4.49
	(14.67)	(14.04)	(12.50)	(12.70)	(17.26)	(16.20)	(14.31)	(14.33)	(12.14)	(11.40)	(9.60)	(9.35)
Intercept	-2.73	-2.83	0.05	0.59	2.57	2.28	3.08	3.05	-5.33	-6.18	-4.62	-5.04
	(-4.11)	(-3.49)	(0.06)	(0.57)	(8.72)	(7.42)	(10.75)	(8.97)	(-13.29)	(-12.94)	(-8.51)	(-8.24)
N	53,935	46,296	39,714	35,701	54,968	47,228	40,633	36,544	53,935	46,296	39,714	35,701
R^2	0.1328	0.1432	0.1352	0.1426	0.1904	0.1963	0.1896	0.1950	0.2220	0.2368	0.2321	0.2455

Table 5. Long-Term Misvaluation Effects: Regressions of Innovative Input, Output and Inventiveness on 3-Year Lagged Stock Misvaluation

The misvaluation measure (*VP* or *MFFlow*) is lagged by 3 years. The variables are defined in Table 1. All independent variables are standardized to have a mean of zero and standard deviation of one. *Novelty*, *Originality*, and *Scope* are in percentage. All regressions include 2-digit SIC industry fixed effects and year fixed effects. *T*-statistics are reported in parentheses. Standard errors are clustered by firm and year. The sample includes U.S. non-financial, non-utility firms listed on NYSE, AMEX and NASDAQ with COMPUSTAT and I/B/E/S coverage during 1976-2012. The patent and citation data (*Pat*, *Cites*, *Novelty*, *Originality*, and *Scope*) sample period is 1976-2008.

	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
	RD		*CAPX*		*Log(1+Pat)*		*Log(1+Cites)*		*Novelty*		*Originality*		*Scope*	
VP	-2.03		0.01		-0.09		-0.04		-4.67		-1.80		-1.16	
	(-11.39)		(0.14)		(-4.73)		(-5.54)		(-5.87)		(-5.39)		(-5.22)	
MFFlow		-1.05		-0.04		-0.08		-0.04		-3.62		-1.30		-0.95
		(-6.50)		(-0.62)		(-6.30)		(-6.91)		(-6.69)		(-5.32)		(-4.77)
GS	1.46	2.00	0.85	1.04	-0.01	-0.01	0.00	0.01	3.23	4.69	0.53	0.87	0.47	0.65
	(4.39)	(5.74)	(4.38)	(5.19)	(-0.95)	(-0.69)	(0.57)	(0.54)	(3.01)	(2.46)	(1.73)	(1.90)	(1.80)	(1.35)
CF	2.18	2.08	2.04	1.92	0.22	0.23	0.09	0.10	8.15	8.47	2.78	2.78	2.78	2.82
	(8.40)	(7.11)	(12.16)	(11.12)	(10.42)	(8.66)	(10.02)	(8.38)	(8.49)	(7.07)	(8.41)	(7.53)	(6.31)	(5.44)
Leverage	-1.01	-1.14	0.47	0.45	-0.19	-0.21	-0.08	-0.08	-6.25	-6.00	-2.32	-2.31	-2.47	-2.15
	(-8.50)	(-8.41)	(4.87)	(4.34)	(-9.81)	(-8.79)	(-10.09)	(-8.71)	(-8.17)	(-6.81)	(-8.32)	(-7.05)	(-9.75)	(-7.55)
Log(Age)	-0.94	-1.43	-0.72	-0.49	0.20	0.17	0.08	0.06	2.28	0.13	2.83	2.28	2.31	1.57
	(-5.02)	(-6.15)	(-4.22)	(-2.69)	(5.70)	(3.98)	(5.46)	(3.54)	(1.94)	(0.09)	(5.52)	(3.53)	(4.91)	(2.87)
Size	-2.17	-2.54	0.23	0.09	0.75	0.78	0.26	0.26	13.26	12.82	5.38	5.32	4.73	4.40
	(-9.05)	(-9.91)	(1.84)	(0.75)	(18.34)	(16.09)	(19.16)	(17.02)	(13.41)	(11.75)	(14.47)	(12.40)	(9.60)	(8.14)
Intercept	6.82	7.58	7.20	7.05	-0.32	-0.33	-0.15	-0.14	-2.76	0.47	2.06	2.77	-6.48	-5.55
	(45.56)	(42.75)	(33.60)	(31.83)	(-11.25)	(-8.95)	(-13.55)	(-9.68)	(-2.90)	(0.40)	(5.67)	(6.35)	(-10.30)	(-7.24)
N	27,344	21,022	42,460	32,118	36,057	26,274	35,181	25,510	35,181	25,510	36,002	26,235	35,181	25,510
R^2	0.3272	0.3093	0.1279	0.1211	0.4231	0.4300	0.3934	0.4034	0.1511	0.1577	0.2012	0.2055	0.2547	0.2783

Table 6. Path Analysis of the Effects of Misvaluation on R&D or Capital Investment

This analysis is based on a sample during 1976-2012. The variables in Panel A are defined in Table 1. In Panel B, *ROA* is operating income before depreciation and R&D expenses scaled by total assets for the prior fiscal year, and *ΔCR* is change in the current ratio (total current assets divided by total current liabilities). All variables are not standardized. All regressions include industry and year fixed effects. *T*-statistics are reported in parentheses. Standard errors are clustered by firm and year. We follow Badertscher, Shanthikumar, and Teoh (2016) to break the total effect of *MFFlow* on investment into two parts: the direct catering effect, and the indirect effect through the equity issuance channel.

Panel A. Investment (*RD* or *CAPX*) regression

	RD	*CAPX*
MFFlow	-19.8209	-4.1831
	(-5.66)	(-2.47)
EI	0.1399	0.0370
	(11.88)	(8.79)
GS	0.3003	0.2100
	(4.04)	(3.57)
CF	0.1244	0.1273
	(9.18)	(12.31)
Leverage	-6.1409	2.2727
	(-10.91)	(5.72)
Log(Age)	-0.9448	-0.4831
	(-6.09)	(-3.41)
Size	-1.1609	0.0820
	(-9.68)	(1.17)
Intercept	15.5566	5.2773
	(18.29)	(12.69)
N	27,952	43,183
R^2	0.4305	0.1307

Panel B. Equity Issuance (*EI*) regression

	EI
MFFlow	-42.8982
	(-8.55)
GS	1.0358
	(7.62)
ROA	-0.1717
	(-5.63)
ΔCR	3.3164
	(4.00)
Leverage	-3.8942
	(-2.84)
Log(Age)	-1.4671
	(-4.56)
Size	-2.2261
	(-12.95)
Intercept	28.2340
	(14.53)
N	42,381
R^2	0.1207

Panel C. Path analysis results for the effects of *MFFlow* on *RD* or *CAPX*.

(1) Direct Effect of *MFFlow* on Investment					
MFFlow → *RD*	Coefficient	*T*-stat	*MFFlow* → *CAPX*	Coefficient	*T*-stat
	-19.8209	(-5.66)		-4.1831	(-2.47)
(2) Indirect Effect of *MFFlow* on Investment via Equity Channel					
MFFlow → *EI*	-42.8982	(-8.55)	*MFFlow* → *EI*	-42.8982	(-8.55)
EI → *RD*	0.1399	(11.88)	*EI* → *CAPX*	0.0370	(8.79)
Equity Path Effect	-6.0015		Equity Path Effect	-1.5872	
(3) Total *MFFlow*			Total *MFFlow*		
Effect on RD	-25.8224		Effect on *CAPX*	-5.7703	
% Direct Path	76.76%		% Direct Path	72.49%	
% Equity Path	23.24%		% Equity Path	27.51%	

Table 7. Regressions of Innovative Input, Output and Inventiveness on Stock Misvaluation: Interaction with Overvaluation

The misvaluation measure (*VP* or *MFFlow*) is interacted with an overvaluation indicator. *LowVP* (*LowFlow*) is an indicator variable for the lowest *VP* (*MFFlow*) quintile. The variables are defined in Table 1. All independent variables are standardized to have a mean of zero and standard deviation of one. *Novelty*, *Originality*, and *Scope* are in percentage. All regressions include 2-digit SIC industry fixed effects and year fixed effects. *T*-statistics are reported in parentheses. Standard errors are clustered by firm and year. The sample includes U.S. non-financial, non-utility firms listed on NYSE, AMEX and NASDAQ with COMPUSTAT and I/B/E/S coverage during 1976-2012. The patent and citation data (*Pat*, *Cites*, *Novelty*, *Originality*, and *Scope*) sample period is 1976-2008.

	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
	RD		*CAPX*		*Log(1+Pat)*		*Log(1+Cites)*		*Novelty*		*Originality*		*Scope*	
VP	-0.19		-0.53		-0.04		-0.02		-3.09		-1.08		-0.93	
	(-0.98)		(-5.00)		(-1.96)		(-2.86)		(-4.04)		(-3.56)		(-3.70)	
*VP*LowVP*	-6.53		0.34		-0.19		-0.07		-9.23		-3.33		-2.67	
	(-13.45)		(2.46)		(-7.38)		(-6.89)		(-7.00)		(-7.38)		(-5.74)	
MFFlow		-0.96		-0.28		-0.05		-0.02		-2.51		-0.85		-0.87
		(-6.49)		(-3.30)		(-5.48)		(-6.17)		(-5.77)		(-4.13)		(-5.70)
*MFFlow*LowFlow*		-4.87		-0.24		-0.43		-0.16		-12.21		-4.03		-5.29
		(-8.12)		(-1.09)		(-5.52)		(-5.81)		(-4.50)		(-3.74)		(-6.16)
GS	0.78	1.00	0.58	0.54	0.03	0.02	0.02	0.02	3.00	3.60	0.50	0.73	0.58	0.71
	(5.36)	(5.26)	(4.40)	(4.13)	(3.86)	(2.96)	(4.81)	(4.16)	(5.46)	(5.75)	(2.90)	(3.81)	(3.61)	(3.97)
CF	2.56	1.94	2.01	1.87	0.19	0.18	0.08	0.08	8.13	7.77	2.59	2.31	2.58	2.40
	(11.97)	(7.36)	(11.16)	(11.58)	(12.61)	(10.54)	(12.54)	(10.43)	(11.21)	(9.13)	(11.59)	(8.69)	(8.50)	(6.97)
Leverage	-1.23	-1.37	0.63	0.51	-0.19	-0.21	-0.08	-0.08	-6.81	-7.19	-2.51	-2.78	-2.65	-2.66
	(-11.31)	(-10.81)	(6.45)	(5.56)	(-11.66)	(-10.99)	(-12.28)	(-11.42)	(-11.19)	(-10.12)	(-10.78)	(-9.97)	(-11.27)	(-10.25)
Log(Age)	-0.63	-1.19	-0.77	-0.57	0.20	0.16	0.08	0.06	3.82	1.64	2.77	2.25	2.60	1.98
	(-4.28)	(-6.11)	(-5.22)	(-3.60)	(7.30)	(5.26)	(7.17)	(4.94)	(3.66)	(1.43)	(6.96)	(4.66)	(6.64)	(4.68)
Size	-1.92	-2.71	0.11	-0.01	0.70	0.74	0.25	0.26	13.39	13.07	5.45	5.41	4.94	4.65
	(-9.74)	(-11.56)	(0.92)	(-0.06)	(19.98)	(18.05)	(21.15)	(19.20)	(14.77)	(13.41)	(16.80)	(14.72)	(11.70)	(9.86)
Intercept	5.42	7.08	7.39	7.20	-0.22	-0.21	-0.12	-0.10	-3.46	0.17	2.05	2.92	-6.37	-5.22
	(30.98)	(44.31)	(36.20)	(33.58)	(-10.25)	(-8.17)	(-14.29)	(-9.77)	(-3.94)	(0.17)	(6.61)	(8.47)	(-12.51)	(-8.61)
N	34,658	27,982	54,445	43,253	47,295	36,598	46,296	35,701	46,296	35,701	47,228	36,544	46,296	35,701
R^2	0.3690	0.3177	0.1277	0.1182	0.4127	0.4144	0.3819	0.3827	0.1454	0.1437	0.1987	0.1960	0.2384	0.2475

Table 8. Regressions of Investments and Innovative Output on Stock Misvaluation: Interaction with Growth or Turnover

The misvaluation measure (*VP* or *MFFlow*) is interacted with growth (*GS*) or share turnover (*Turnover*). *HighGS* (*HighTurn*) is an indicator variable for the highest *GS* (*Turnover*) quintile. The variables are defined in Table 1. All independent variables are standardized to have a mean of zero and standard deviation of one. All regressions include 2-digit SIC industry fixed effects and year fixed effects. *T*-statistics are reported in parentheses. Standard errors are clustered by firm and year. The sample includes U.S. non-financial, non-utility firms listed on NYSE, AMEX and NASDAQ with COMPUSTAT and I/B/E/S coverage during 1976-2012. The patent and citation (*Pat* and *Cites*) data sample period is 1976-2008.

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	RD				*CAPX*				*Log(1+Pat)*				*Log(1+Cites)*			
VP	-2.20		-2.45		-0.42		-0.34		-0.09		-0.08		-0.04		-0.04	
	(-11.13)		(-12.96)		(-3.81)		(-3.19)		(-4.27)		(-4.62)		(-4.90)		(-5.40)	
*VP*HighGS*	-1.35				-0.02				-0.06				-0.04			
	(-4.44)				(-0.10)				(-3.49)				(-5.49)			
*VP*HighTurn*			0.06				0.19				-0.08				-0.03	
			(0.25)				(1.22)				(-2.72)				(-2.98)	
MFFlow		-1.25		-1.08		-0.23		-0.16		-0.07		-0.05		-0.03		-0.02
		(-6.50)		(-6.08)		(-2.79)		(-2.22)		(-5.28)		(-4.98)		(-5.85)		(-5.60)
*MFFlow*HighGS*		-0.23				-0.58				-0.03				-0.02		
		(-0.97)				(-2.11)				(-1.19)				(-2.00)		
*MFFlow*HighTurn*				-1.25				-0.51				-0.24				-0.09
				(-2.97)				(-2.19)				(-4.84)				(-4.76)
GS	0.77	1.03	0.79	0.96	0.57	0.52	0.48	0.47	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01
	(4.89)	(5.46)	(4.99)	(5.18)	(4.41)	(3.99)	(4.00)	(3.80)	(3.53)	(3.28)	(3.68)	(2.67)	(4.28)	(4.29)	(4.44)	(3.68)
CF	1.92	1.86	1.88	1.81	2.04	1.87	1.93	1.82	0.17	0.18	0.17	0.17	0.07	0.08	0.07	0.07
	(8.68)	(6.90)	(8.77)	(7.02)	(11.65)	(11.53)	(11.85)	(11.44)	(11.69)	(9.92)	(11.95)	(10.26)	(11.76)	(9.91)	(11.99)	(10.12)
Leverage	-1.17	-1.37	-1.20	-1.35	0.63	0.51	0.57	0.51	-0.18	-0.21	-0.19	-0.21	-0.08	-0.08	-0.08	-0.08
	(-10.66)	(-10.30)	(-10.88)	(-10.69)	(6.30)	(5.61)	(6.26)	(5.65)	(-11.39)	(-10.82)	(-11.16)	(-10.78)	(-11.98)	(-11.24)	(-11.82)	(-11.24)
Log(Age)	-0.84	-1.25	-0.83	-1.12	-0.75	-0.57	-0.67	-0.49	0.19	0.15	0.19	0.16	0.08	0.06	0.07	0.06
	(-5.21)	(-6.59)	(-5.22)	(-5.53)	(-5.11)	(-3.59)	(-4.53)	(-3.13)	(7.00)	(4.99)	(6.99)	(5.23)	(6.92)	(4.73)	(6.90)	(5.02)
Size	-2.36	-2.89	-2.57	-3.11	0.13	-0.01	-0.07	-0.21	0.69	0.72	0.69	0.71	0.24	0.25	0.24	0.24
	(-10.43)	(-11.24)	(-10.39)	(-11.51)	(1.12)	(-0.09)	(-0.58)	(-1.74)	(19.62)	(17.55)	(18.92)	(17.66)	(20.67)	(18.43)	(19.69)	(18.34)
Turnover			0.66	0.58			0.73	0.63			0.03	0.02			0.02	0.02
			(3.49)	(2.58)			(6.61)	(6.05)			(0.99)	(0.56)			(1.90)	(1.44)
Intercept	6.93	7.31	6.73	7.02	7.32	7.19	6.97	6.88	-0.21	-0.19	-0.24	-0.22	-0.11	-0.10	-0.14	-0.12
	(51.87)	(49.43)	(49.21)	(41.70)	(37.01)	(33.90)	(41.13)	(36.60)	(-9.80)	(-7.53)	(-6.41)	(-4.73)	(-14.34)	(-9.13)	(-8.95)	(-6.30)
N	34,658	27,982	33,945	27,982	54,445	43,253	53,286	43,253	47,295	36,598	46,152	36,598	46,296	35,701	45,155	35,701
R^2	0.3253	0.3099	0.3276	0.3137	0.1275	0.1187	0.1273	0.1243	0.4106	0.4109	0.4132	0.4127	0.3803	0.3800	0.3844	0.3823

Table 9. Regressions of Innovative Novelty, Originality and Scope on Stock Misvaluation: Interaction with Growth or Turnover

The variables are defined in Table 1. The misvaluation measure (*VP* or *MFFlow*) is interacted with growth (*GS*) or share turnover (*Turnover*). *HighGS* (*HighTurn*) is an indicator variable for the highest GS (turnover) quintile. All independent variables are standardized to have a mean of zero and standard deviation of one. *Novelty*, *Originality*, and *Scope* are in percentage. All regressions include 2-digit SIC industry fixed effects and year fixed effects. *T*-statistics are reported in parentheses. Standard errors are clustered by firm and year. The sample includes U.S. non-financial, non-utility firms listed on NYSE, AMEX and NASDAQ with COMPUSTAT, I/B/E/S, and patent-citation data coverage during 1976-2008.

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Novelty				*Originality*				*Scope*			
VP	-4.55		-4.91		-1.72		-1.89		-1.40		-1.54	
	(-5.99)		(-6.17)		(-5.20)		(-5.43)		(-5.42)		(-5.79)	
*VP*HighGS*	-7.60				-2.18				-1.95			
	(-7.82)				(-7.21)				(-5.85)			
*VP*HighTurn*			-4.31				-1.31				-1.29	
			(-3.41)				(-3.40)				(-3.28)	
MFFlow		-2.84		-2.22		-1.00		-0.85		-1.07		-0.96
		(-5.59)		(-4.92)		(-3.86)		(-3.76)		(-5.37)		(-5.54)
*MFFlow*HighGS*		-4.19				-0.95				-1.18		
		(-3.23)				(-1.93)				(-3.43)		
*MFFlow*HighTurn*				-8.40				-2.97				-4.01
				(-4.61)				(-4.88)				(-4.49)
GS	2.64	3.54	2.68	3.19	0.40	0.73	0.47	0.67	0.49	0.72	0.59	0.71
	(5.09)	(5.72)	(5.21)	(5.36)	(2.38)	(3.71)	(2.95)	(3.53)	(3.04)	(3.98)	(3.80)	(3.95)
CF	7.35	7.62	6.96	7.27	2.30	2.26	2.25	2.20	2.35	2.34	2.34	2.31
	(10.43)	(8.83)	(10.03)	(8.57)	(10.52)	(8.31)	(10.07)	(8.08)	(8.10)	(6.67)	(8.20)	(6.79)
Leverage	-6.57	-7.16	-6.74	-7.06	-2.44	-2.77	-2.49	-2.74	-2.58	-2.66	-2.65	-2.63
	(-10.75)	(-10.07)	(-11.25)	(-10.34)	(-10.41)	(-9.87)	(-10.71)	(-9.96)	(-11.03)	(-10.08)	(-11.03)	(-10.01)
Log(Age)	3.63	1.53	3.79	2.09	2.69	2.22	2.71	2.31	2.54	1.93	2.46	1.99
	(3.46)	(1.35)	(3.52)	(1.78)	(6.65)	(4.58)	(6.38)	(4.63)	(6.46)	(4.51)	(6.18)	(4.69)
Size	12.83	12.72	12.04	11.67	5.25	5.29	5.14	5.12	4.78	4.50	4.76	4.45
	(14.02)	(12.74)	(12.06)	(10.83)	(16.20)	(14.36)	(14.61)	(12.96)	(11.42)	(9.35)	(11.41)	(9.60)
Turnover			3.55	3.23			0.55	0.39			0.08	-0.13
			(3.83)	(3.31)			(1.52)	(1.02)			(0.34)	(-0.55)
Intercept	-3.08	0.48	-6.78	-3.67	2.22	3.03	1.67	2.45	-6.25	-5.07	-6.20	-5.08
	(-3.81)	(0.46)	(-4.80)	(-2.15)	(7.14)	(8.87)	(3.11)	(3.82)	(-13.11)	(-8.31)	(-9.64)	(-6.68)
N	46,296	35,701	45,155	35,701	47,228	36,544	46,085	36,544	46,296	35,701	45,155	35,701
R^2	0.1447	0.1429	0.1469	0.1457	0.1973	0.1951	0.1975	0.1963	0.2377	0.2457	0.2394	0.2471

Table 10. Quantile Regressions

We perform quantile regressions of R&D, CAPX, and innovative output (*Pat* and *Cites*) and inventiveness variables (*Novelty*, *Originality* and *Scope*) on misvaluation (measured by *VP* as in Panel A, or by *MFFlow* as in Panel B) and control variables with industry and year fixed effects. We choose quantile values of Q to be 0.2, 0.4, 0.6, and 0.8 for *RD* and *CAPX*; and quantile values of 0.65, 0.7, 0.75, and 0.8 for innovative output and inventive measures because these variables have a median value of zero. We report only the coefficient on *VP* (Panel A) or *MFFlow* (Panel B). *T*-statistics of the *VP* or *MFFlow* coefficient of the quantile regressions are reported in parentheses, with *p*-values of the *F*-test for the difference in the coefficients between the top or bottom quantiles shown in square brackets.

Panel A. Misvaluation measured by *VP*.

	Q(0.2)	*Q*(0.4)	*Q*(0.6)	*Q*(0.8)	*Q*(0.8)-*Q*(0.2) [*p*-value]
RD	-0.414	-1.105	-1.637	-2.038	-1.624
	(-33.11)	(-43.04)	(-39.66)	(-29.53)	[0.000]
CAPX	0.002	-0.073	-0.233	-0.528	-0.530
	(-0.14)	(-4.21)	(-8.08)	(-9.18)	[0.000]

	Q(0.65)	*Q*(0.7)	*Q*(0.75)	*Q*(0.8)	*Q*(0.8)-*Q*(0.65) [*p*-value]
Pat	-0.079	-0.098	-0.121	-0.134	-0.055
	(-10.71)	(-11.68)	(-12.03)	(-12.82)	[0.000]
Cites	-0.039	-0.050	-0.061	-0.069	-0.030
	(-11.85)	(-14.40)	(-14.52)	(-17.65)	[0.000]
Novelty	-2.147	-3.604	-5.805	-7.781	-5.634
	(-9.23)	(-11.96)	(-12.81)	(-12.59)	[0.000]
Originality	-0.427	-1.477	-2.799	-3.760	-3.333
	(-10.00)	(-10.76)	(-11.60)	(-13.36)	[0.000]
Scope	-0.893	-1.936	-2.963	-3.300	-2.407
	(-9.44)	(-15.15)	(-18.57)	(-20.26)	[0.000]

Panel B. Misvaluation measured by *MFFlow*.

	Q(0.2)	*Q*(0.4)	*Q*(0.6)	*Q*(0.8)	*Q*(0.8)-*Q*(0.2) [*p*-value]
RD	-0.117	-0.483	-0.829	-1.120	-1.003
	(-9.95)	(-19.49)	(-18.47)	(-13.96)	[0.000]
CAPX	-0.002	-0.058	-0.157	-0.366	-0.364
	(-0.17)	(-3.26)	(-5.17)	(-6.36)	[0.000]

	Q(0.65)	*Q*(0.7)	*Q*(0.75)	*Q*(0.8)	*Q*(0.8)-*Q*(0.65) [*p*-value]
Pat	-0.062	-0.068	-0.068	-0.072	-0.010
	(-7.23)	(-7.84)	(-6.61)	(-5.71)	[0.102]
Cites	-0.030	-0.033	-0.034	-0.040	-0.011
	(-9.09)	(-8.42)	(-6.93)	(-7.38)	[0.000]
Novelty	-1.379	-2.050	-2.757	-3.772	-2.393
	(-5.95)	(-5.14)	(-4.83)	(-5.01)	[0.000]
Originality	-0.158	-0.620	-1.273	-1.497	-1.339
	(-4.42)	(-4.04)	(-4.29)	(-5.12)	[0.000]
Scope	-0.789	-1.279	-1.751	-1.923	-1.134
	(-7.74)	(-8.56)	(-11.00)	(-12.53)	[0.000]