


# Misvaluation and Corporate Inventiveness

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## Abstract

We test how market overvaluation affects corporate innovation. Estimated stock overvaluation is strongly associated with measures of innovative inventiveness (novelty, originality, and scope), as well as research and development (R&D) and innovative output (patent and citation counts). Misvaluation affects R&D more via a nonequity channel than via equity issuance. The sensitivity of innovative inventiveness to misvaluation increases with share turnover and overvaluation. 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 encouraging firms to engage in “moon shots.”

## I. Introduction

Both efficient and inefficient market theories imply that higher stock prices are associated with higher corporate investment. This includes both the creation of tangible assets through capital expenditures and the creation of intangible assets

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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 firms differently. Under what we call the *misvaluation hypothesis of innovation*, firms respond to market overvaluation by engaging in more innovative activities, resulting in more risky and creative forms of innovation, and higher innovative investment and future innovative output.

With regard to the ambitiousness of firms' innovative activities, the management of an overvalued firm may have greater freedom to engage in more ambitious projects with 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, because innovative activities tend to create positive externalities, overvaluation may sometimes be welfare improving, as suggested by Keynes (1931) and Gross (2009).<sup>1</sup>

To test for such effects, we measure both the amount of innovative output (i.e., 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 is associated with three aspects of innovativeness defined in the literature. Innovative novelty is the number of citations per patent (Seru (2014)), innovative originality is the extent to which a patent cites previous patents spanning a wide range of technology classes, and 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)).<sup>2</sup> 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 II the co-occurrence of overvaluation and innovative activity using the case examples of Tesla, SpaceX, and NetApp.

Overvaluation can also potentially increase the investment level, both in general and in innovative activity. For example, overvaluation can encourage the firm to raise more equity capital (Stein (1996), Baker, Stein, and Wurgler (2003),

<sup>1</sup>See also Shleifer, A. "Are Markets Efficient?" *Wall Street Journal* (Dec. 28, 2000), A10.

<sup>2</sup>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. The 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 (2018).

and Gilchrist, Himmelberg, and Huberman (2005)) to exploit new shareholders.<sup>3</sup> 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 to obtain favorable terms for new equity (or risky debt) financing.

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; this is 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 short-term investor optimism about the investment opportunities that investors find appealing (Stein (1996), Jensen (2005), and Polk and Sapienza (2009)). Managers may also be motivated to maintain high stock prices (Jensen (2005)), in part because high prices serve as a reference point for investor perceptions (Baker, Pan, and Wurgler (2012), Li and Yu (2012), and George, Hwang, and Li (2018)).

Crucially, even if investor optimism is transient, according to the catering theory it affects current levels of long-term investment such as capital expenditures because managers desire credit for generating long-term value.<sup>4</sup> 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. **Section III.B** documents that there are long-run effects of overvaluation on innovation.

Two other behavioral mechanisms can also induce an association between misvaluation and innovative activity. First, managers themselves may share in the positive sentiment of investors, which 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 (see, e.g., Hirshleifer, Subrahmanyam, 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

<sup>3</sup>Because equity is more sensitive than debt to firm valuations, equity is a more attractive vehicle for exploiting misvaluation. 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, Hirshleifer, Richardson, and Teoh (2006)), as predicted by the behavioral model of Shleifer and Vishny (2003).

<sup>4</sup>Several empirical papers document investor sensitivity to 52-week highs, and some also provide evidence that this influences managerial behavior (Baker et al. (2012), Li and Yu (2012), Birru (2015), and George et al. (2018)).

resulting innovative output is important because 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).

A key challenge for estimating the relation between inventiveness, and innovative inputs/outputs to misvaluation is that valuation is endogenous; in an efficient market, firms with strong opportunities for innovative investment 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 a measure of misvaluation designed to exclude, as much as possible, this rational component of valuation.

Our misvaluation measure, 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. Because MFFLOW is not based on market price, it is especially helpful for addressing the previously mentioned endogeneity problem: that high price reflects opportunities for innovative investment.

Although our misvaluation proxy is designed to exclude the contaminating effects of growth prospects that are unrelated to misvaluation, we include several controls for such opportunities in all our tests, as well as perform robustness checks based on conservative filtering of the MFFLOW variable. If market participants tend to overvalue firms with good growth prospects, including growth controls in our regressions will eliminate some of the misvaluation effect we seek to measure. Nevertheless, the effects of misvaluation that we document are strong.

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 undervalued firms more undervalued. Therefore, letting  $x$  be the level of overvaluation (possibly negative), firms with low MFFLOW have a higher distribution of  $x$  (in the sense of first-order stochastic dominance) than firms with high MFFLOW. Crucially, the measure captures variation in misvaluation even within the deep overvaluation range, not just in the undervaluation range.

Moreover, our MFFLOW measure is immune to the criticism of the original Edmans et al. (2012) measure: that there is a possible mechanical correlation with contemporaneous returns (Wardlaw (2020)) (see the Appendix for details).<sup>5</sup> Wardlaw (2020) also suggests that the fund flow measure may be influenced by share turnover. It is unclear whether this is a drawback or a strength of this measure, as past studies have provided evidence that share turnover is associated

<sup>5</sup>Outflows are multiplied by market values at the end rather than the beginning of the quarter as in the original Edmans et al. (2012) measure, and then scaled by volume at the end of the quarter. Using market values and volume at the end of the quarter avoids a mechanical contemporaneous return embedded in the measure. Other studies use similar fund-flow-based price pressure measures that are free of contemporaneous returns (see Section II).

with misvaluation (e.g., Lee and Swaminathan (2000), Baker and Stein (2004)), which is what the flow measure is intended to capture. Nonetheless, to investigate whether the effects we identify are incremental to share turnover effects, we perform tests using residual MFFLOW, or fund flow that is orthogonal to turnover. These tests, reported in the Supplementary Material, confirm that our findings are robust to controlling for turnover.

As a further robustness check, we perform tests using an alternative misvaluation proxy,  $VP$ , defined as the ratio of intrinsic value ( $V$ ) to market price  $P$  (also reported in the Supplementary Material).  $V$  is a forward-looking measure of fundamental value derived from the residual income model of Ohlson (1995) using analyst forecasts of future earnings.<sup>6</sup> Notably, we obtain similar results using a misvaluation proxy that is motivated and constructed very differently from MFFLOW.

We perform four 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. Second, we estimate whether the relation between misvaluation and innovative spending operates more through external financing versus nonfinancing mechanisms. Third, we examine how the sensitivity of innovative activities to misvaluation varies with share turnover, which as we indicate earlier is a proxy for catering incentives, and with misvaluation itself. Fourth, we perform quantile regressions to test whether misvaluation affects the propensity toward extremes of high innovation.

With regard to the first issue, 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 larger than or comparable to the sensitivity to growth in sales and cash flow. Turning 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. Therefore, misvaluation affects the qualitative nature, as well as the quantity, of innovative activity.

Second, to assess the relative importance of equity and debt financing versus other channels through which misvaluation can affect innovation, we conduct a path analysis of the R&D response to misvaluation (see Badertscher, Shanthikumar, and Teoh (2019)). We find that more than two-thirds of the total effect of misvaluation on R&D spending derives from the nonfinancing channel. The remaining misvaluation effect operates mostly through equity issuance, with risky debt financing the least important channel in influencing innovation.

The evidence that overvaluation induces firms to raise cheap equity capital to finance intangible investment is consistent with the models of Stein (1996) and

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<sup>6</sup>This measure is used as a proxy for misvaluation in several studies (D'Mello and Shroff (2000), Dong et al. (2006), Dong et al. (2012), and Ma (2019)). A key advantage of  $V$  as a measure of fundamental value as compared to, for example, 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.

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 the shared sentiment effects discussed earlier. The larger magnitudes of the nonfinancing channel suggest that catering and/or shared sentiment effects of misvaluation may be particularly strong.

Third, we dig more deeply into the misvaluation effect by testing whether the catering incentive and overvaluation itself affect the sensitivities of innovative spending and outcomes to misvaluation. We first interact our misvaluation measure with an indicator for firms in the highest quintile for equity catering pressure as proxied by share turnover. We find that the three types of innovative inventiveness (novelty, originality, and scope), as well as R&D spending and innovative output measures, are more sensitive to overvaluation among high-turnover firms. This evidence is consistent with the idea that the effects of misvaluation on innovation activity and inventiveness are especially important among firms with higher catering incentives (Polk and Sapienza (2009)).

Furthermore, our results suggest that the relations between misvaluation and innovative inputs, outputs, and inventiveness measures are convex. We find that overvaluation promotes innovation more strongly than undervaluation reduces innovation, which suggests that the ex ante prospect of strong misvaluation may on average increase social welfare.

Finally, we provide further verification of our findings by running quantile regressions, which are less sensitive to the influences of outliers and distributional assumptions. The results are robust and indicate that variation in misvaluation has an especially strong effect in increasing the frequency of unusually high innovative outcomes. Collectively, these findings indicate that overvaluation encourages firms to engage in moon shot projects in the sense of very high inventiveness and expected innovative output.<sup>7</sup>

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)). Our findings do not speak to whether the benefits of higher innovation are worth the cost. However, these findings do reinforce other evidence that behavioral biases, such as managerial overconfidence, sometimes promote innovation (Hirshleifer, Low, and Teoh (2012)).

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 (see Barro (1990), Blanchard, Rhee, and Summers (1993), Morck, Shleifer, and Vishny (1990), Welch and Wessels (2000), Baker et al. (2003), Gilchrist, Himmelberg, and Huberman (2005), Polk and Sapienza (2009), Hau and Lai (2013), Parise (2013), Altı and Tetlock (2014), and Warusawitharana and Whited (2016)).

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<sup>7</sup>In discussing what he views as a period of overvaluation by many firms, Keynes (1931) writes, "While 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..."



Most of these studies focus 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. In [Section II](#), we compare our misvaluation proxies to others used in the literature. Finally, a large literature investigates the economic factors that drive innovation (see, e.g., Acharya and Xu (2017) and references therein). Building on this research, we describe how market misvaluation affects innovation.

## II. Data, Empirical Measures, and Test Design

Our sample includes U.S. firms listed on New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and National Association of Securities Dealers Automated Quotations (NASDAQ) that are covered by Center for Research in Security Prices (CRSP) and Compustat, and are subject to the following restrictions. We require firms to have the mutual fund flows measure (MFFLOW) from CDA/Spectrum and CRSP. Consequently, our sample starts from 1981 when CDA/Spectrum reporting begins. Finally, we exclude financial firms (firms with 1-digit Standard Industrial Classification (SIC) code 6) and utility firms (2-digit SIC code 49). Our final sample has 63,488 total firm-year observations with nonmissing MFFLOW measure from 1981 to 2012.

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

### A. Measures of Innovative Output and Inventiveness

Patent and citation data are constructed from the Nov. 2011 edition of the patent database of Kogan, Papanikolaou, Seru, and Stoffman (2017). This database covers U.S. patent grants and patent citations up to 2010. On average, there is a 2-year lag between patent application and patent grant. Because 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 applied for in a fiscal year (PAT) that are ultimately successful (even if the grant occurs after the application fiscal year). However, simple patent counts imperfectly capture innovation success because patent innovations vary widely in their technological and economic importance. Following Hall et al. (2001), (2005), we measure the importance of patents by their citation counts (CITES), measured as the sum of raw citation counts ultimately received by patents applied for each year (even if those citations are obtained after the patent application year), scaled by the average citation counts of all patents applied for in the same year and technology class. In our regression tests, we use log transformed values of PAT and CITES to limit outlier effects.

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 received over time (including subsequent years). It is a natural way to capture the importance of the innovations generated by the firm.

Following Trajtenberg et al. (1997), we define ORIGINALITY of a patent as 1 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 is 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), and Singh and Fleming (2010)). Under this view, useful new ideas come from combining existing ideas 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 et al. (1997), SCOPE of a patent is defined as 1 minus the Herfindahl index across technological classes of future citations of the patent. This reflects the extent to which a patent has 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 technological applications. Each of the three inventiveness measures is the firm-level average over the patents' respective inventiveness scores. The innovative output (PAT and CITES) and inventiveness (NOVELTY, ORIGINALITY, and SCOPE) measures are for a given patent application year and therefore include the grant and citations received after 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.<sup>8</sup> 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 in less than a year, from 2013 to 2014, 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 Oct. 16, 2017 (Sorkin (2017)). Gornall and Strebulaev (2017) point out that the valuations of many unicorns such as SpaceX are grossly inflated owing to valuations based on recently issued shares with special cash-flow rights.<sup>9</sup>

<sup>8</sup>NetApp, a multinational storage and data management company, is an example within our sample. Just before 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.

<sup>9</sup>Because these valuations are not based on market prices for common shares, such overvaluation need not imply 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



## B. Investment and Control Variables

We measure firms' investment activities using the R&D (item XRD) and capital expenditure (item 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, including those described next, are winsorized at the 1st and 99th percentiles to mitigate the influence of outliers.

We use equity and debt issuance variables to examine the financing channels of the effect of misvaluation on innovative investment. Following Baker and Wurgler (2002), equity issuance (EI) is calculated as  $[\Delta \text{book equity (Compustat item CEQ)} + \Delta \text{deferred taxes (item TXDB)} - \Delta \text{retained earnings (item RE)}]$  scaled by lagged assets, and debt issuance (DI) is the change in assets minus the change in book equity  $[\Delta \text{total assets (item AT)} - \Delta \text{book equity (item CEQ)} - \Delta \text{deferred taxes (item TXDB)}]$  scaled by lagged assets. These are net issuance variables.

In the multivariate tests, we control for other investment determinants. These control variables include growth rate in sales in the past 3 years (GS), book-equity-to-price ratio (BP), cash flow [ $\text{item IB} + \text{item DP} + \text{item XRD}$ ] scaled by lagged assets [missing XRD is set to 0 to conserve nonmissing cash-flow observations], to control for the ability of the firm to generate cash from operations to fund investment. We include leverage (LEV) defined as  $(\text{item DLTT} + \text{item DLC}) / (\text{item DLTT} + \text{item DLC} + \text{item SEQ})$ . Finally, we control for firm age and size (logarithm of lagged total assets) per DeAngelo, DeAngelo, and Stulz's (2010) finding that mature firms are less likely to issue new equity. Following DeAngelo et al., 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).

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.<sup>10</sup>

Table 1 reports summary statistics for these control variables, and Table 2 reports yearly descriptive information for our sample during 1981–2012. 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, in contrast, have wider fluctuations but generally increase over time, and decline slightly after 2001. As mentioned in Section I, after 1996, RD overtakes CAPX as the larger component of corporate

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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. See Sorkin (2017).

<sup>10</sup>As is standard, to ensure comparability we divide NASDAQ trading volume by 2 (LaPlante and Muscarella (1997)).

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

The sample in Table 1 includes U.S. non-financial firms listed on New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and National Association of Securities Dealers Automated Quotations (NASDAQ) with Compustat and CDA/Spectrum mutual fund flows data during 1981–2012. Patent and citation counts data (Nov. 2011 version) are provided by Kogan, Papanikolaou, Seru, and Stoffman (2017). 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 research and development (R&D) expenditures scaled by lagged total assets (RD). Capital expenditures scaled by lagged total assets (CAPX) is also reported for comparison. 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), number of citations per patent (NOVELTY), and patent-citation quality measures as defined by Hall, Jaffe, and Trajtenberg (2001) (ORIGINALITY and SCOPE). MFFLOW is the mutual fund price pressure measure following Edmans, Goldstein, and Jiang (2012). VP is the residual-income-value-to-price ratio. 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 0 in the CF calculation). LEV 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 the Center for Research in Security Prices (CRSP), truncated at 50. GS is the growth rate of sales in the 3 years before 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, 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. Total assets and sales figures are in 2012 dollars. All ratio variables are winsorized at the 1st (P1) and 99th (P99) percentiles.

Variable	N	Mean	Std. Dev.	Median	P1	P99
<i>Innovation Input and Output Variables</i>						
RD (%)	40,111	9.00	14.08	4.09	0.00	71.97
CAPX (%)	62,893	7.07	8.40	4.54	0.11	43.30
PAT	53,629	12.78	88.11	0.00	0.00	247.00
CITES	52,315	11.59	78.32	0.00	0.00	225.25
NOVELTY	52,315	0.39	0.74	0.00	0.00	3.12
ORIGINALITY	53,550	0.17	0.25	0.00	0.00	0.80
SCOPE	52,315	0.15	0.23	0.00	0.00	0.78
<i>Valuation Variables</i>						
MFFLOW (%)	63,488	3.52	6.01	1.65	0.01	30.52
VP	48,352	0.59	0.53	0.55	-1.09	2.39
<i>Control or Conditioning Variables for Innovation Regressions</i>						
BP	63,187	0.65	0.69	0.46	-0.24	4.11
GS	57,401	0.80	2.28	0.31	-0.75	11.54
CF (%)	63,315	11.33	16.41	11.60	-45.80	56.68
LEV	63,041	0.28	0.27	0.24	0.00	1.24
AGE	63,488	16.25	13.46	12.25	1.25	50.00
ASSETS (\$M)	63,435	3,300.17	18,072.30	395.31	12.16	49,856.18
LTG	40,107	0.18	0.10	0.15	0.04	0.51
EI (%)	63,309	8.45	35.05	0.94	-14.64	163.35
DI (%)	63,435	6.51	23.49	2.16	-34.52	112.83
TURNOVER (%)	63,422	13.21	14.87	7.85	0.39	73.13

investment, growing much larger toward the end of the sample period. These facts highlight the importance of studying R&D activity.

### C. Mispricing Proxy

Our primary proxy for equity misvaluation is the mutual fund outflow price pressure measure, MFFLOW. We summarize estimation procedures here; further details, which are drawn from the literature, are provided in the Appendix. To verify the robustness of our conclusions, we also use several alternative measures described later.

The misvaluation measure, MFFLOW, is derived from mutual fund outflows (Coval and Stafford (2007), Edmans et al. (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

TABLE 2  
Corporate Investment, Innovative Output, and Equity Valuations by Year

Table 2 reports the time pattern of selected variables. The yearly mean values are reported, except for the valuation ratios (book-equity-to-price ratio (BP) and residual-income-value-to-price ratio (VP)) for which the medians are shown. The sample includes U.S. nonfinancial firms listed on the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and National Association of Securities Dealers Automated Quotations (NASDAQ) with Compustat and CDA/Spectrum mutual fund flows data during 1981–2012. Patent and citation data are from Kogan, Papanikolaou, Seru, and Stoffman (2017) (Nov. 2011 version). We end the patent and citation data in 2008 to reduce truncation biases. The variables are defined in Table 1.

Year	<i>N</i>	RD (%)	CAPX (%)	PAT	CITES	NOVELTY	ORIGINALITY	SCOPE	MFFLOW (%)
1981	295	3.98	13.91	38.16	36.15	0.56	0.23	0.25	1.31
1982	707	3.98	9.99	20.44	19.36	0.54	0.20	0.24	5.12
1983	689	4.25	8.43	19.65	18.65	0.50	0.20	0.24	4.36
1984	686	5.73	11.23	18.96	18.45	0.53	0.19	0.23	1.48
1985	1,186	6.00	10.06	12.32	12.36	0.47	0.17	0.21	4.16
1986	1,229	6.18	9.15	11.40	11.53	0.46	0.18	0.21	4.33
1987	1,333	6.26	8.34	11.17	11.13	0.48	0.18	0.21	4.51
1988	1,346	5.85	8.69	12.20	12.15	0.46	0.17	0.20	2.71
1989	1,300	6.07	8.58	13.47	13.45	0.45	0.18	0.21	1.98
1990	1,329	6.80	8.33	13.76	13.87	0.49	0.18	0.21	1.56
1991	1,781	6.38	7.16	10.75	10.96	0.39	0.16	0.18	10.18
1992	1,813	6.91	7.39	11.08	11.52	0.40	0.16	0.18	4.18
1993	1,926	7.73	7.93	11.15	11.51	0.40	0.16	0.18	3.53
1994	2,211	8.18	8.40	10.77	11.15	0.39	0.17	0.18	3.26
1995	2,563	9.23	8.87	11.39	11.55	0.40	0.17	0.18	1.96
1996	2,415	8.86	9.17	12.03	12.44	0.40	0.17	0.17	2.37
1997	2,358	9.65	8.93	14.54	15.13	0.46	0.19	0.19	2.08
1998	2,653	10.13	8.63	13.00	13.32	0.42	0.18	0.17	2.16
1999	2,929	10.97	7.79	12.67	12.80	0.40	0.17	0.16	4.17
2000	2,819	11.33	7.73	13.98	13.95	0.40	0.17	0.15	9.24
2001	2,664	9.20	6.02	15.62	14.93	0.42	0.19	0.14	4.74
2002	2,781	9.80	4.90	15.67	13.76	0.41	0.20	0.13	1.57
2003	2,810	10.39	4.87	15.03	11.84	0.40	0.20	0.10	2.70
2004	2,489	9.40	5.46	15.43	10.83	0.38	0.20	0.08	2.06
2005	2,493	9.55	5.71	14.21	8.30	0.33	0.18	0.06	2.11
2006	2,523	10.68	6.20	11.23	5.27	0.29	0.17	0.04	3.71
2007	2,403	10.12	6.35	7.58	2.85	0.22	0.14	0.02	2.93
2008	2,444	9.69	5.97	3.41	0.94	0.14	0.10	0.01	3.21
2009	2,497	9.64	3.99	–	–	–	–	–	4.21
2010	2,322	9.74	4.86	–	–	–	–	–	3.36
2011	2,265	9.38	5.52	–	–	–	–	–	2.85
2012	2,229	10.07	5.54	–	–	–	–	–	3.25
All	63,488	9.00	7.07	12.78	11.59	0.39	0.17	0.15	3.52

fund manager's private information about the underlying securities, Edmans et al. (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.

In validation of their proxy, Edmans et al. (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 later. Therefore, 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.<sup>11</sup> We therefore follow Edmans et al. and include only outflows.<sup>12</sup>

<sup>11</sup>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. Even recent work that does identify some information in insider selling (Ali and Hirshleifer (2017)) finds that buying is much more informative.

<sup>12</sup>Several other papers employ a mutual fund price pressure measure to study the relation between misvaluation and investment (e.g., Hau and Lai (2013), Parise (2013), Camanho (2015), Lou and Wang

As argued in Edmans et al. (2012), MFFLOW 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' innovative investment strategies. Edmans et al. use hypothetical fund flows to address this 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 et al., we exclude funds that specialize in a given industry. In robustness tests, we also subtract industry MFFLOW or R&D-matched MFFLOW to remove any possible industry effects. Furthermore, in regression tests we include BP, sales growth, or analyst long-term earnings growth forecasts as additional controls for growth.

MFFLOW observations are set to be positive reflecting outflows, so the variable is decreasing with overvaluation. Therefore, a high value of MFFLOW indicates undervaluation. When mutual funds have 0 or close to 0 holdings of a stock, MFFLOW is mechanically equal to 0. 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 et al. (2012). For example, the highest MFFLOW decile experiences a market-adjusted return of roughly  $-12\%$  approximately 2 quarters after the MFFLOW measurement. In contrast, Edmans et al. document a peak price pressure of approximately  $-6.5\%$  market-adjusted return for the decile with the highest outflows.

As discussed in Section I, our measure of MFFLOW is not subject to the concern raised by Wardlaw (2020) of a possible mechanical relation with contemporaneous returns in the flow measure of Edmans et al. (2012). Our modification, which removes any such mechanical effect, is similar to the fund-flow misvaluation measures of Lou and Wang (2018), Li (2019), and Dessaint et al. (2019). For verification that our MFFLOW effects are not just picking up effects of turnover, we perform tests using the residual of the annual regression of MFFLOW on turnover instead of MFFLOW.

As a further robustness check, we perform tests using an alternative misvaluation proxy that involves the estimation of fundamental value of equity, based on the residual income model (Ohlson (1995)). The residual income value  $V$  is estimated as the sum of book value of equity and the stream of discounted analyst forecasted earnings in excess of the firm's cost of equity capital, where the discount rate is the firm's cost of equity.

The residual income value has several 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)). Unlike the book-to-price ratio (BP), VP does not have a mechanical relation with R&D.<sup>13</sup> Furthermore, because  $V$ , like market price and unlike book

(2018), and Dessaint, Foucault, Fresard, and Matray (2019)). Li (2019) also finds evidence supporting the idea that fund flows induce mispricing.

<sup>13</sup>Accounting rules require expensing R&D, which reduces book values, but the market capitalizes R&D so that high-R&D firms tend to have low BP. In contrast, because  $V$  incorporates analyst forecasts

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. In our sample, the correlation of BP with VP is fairly low, 0.22. The Supplementary Material provides results that are robust to using either VP or residual MFFLOW as an alternative mispricing proxy.

Some misvaluation proxies used in past studies include discretionary accruals (Polk and Sapienza (2009)) and dispersion in analyst forecasts of earnings (Gilchrist et al. (2005)).<sup>14</sup> The intuition for these variables is appealing. However, it is also useful to test for misvaluation effects using MFFLOW, which arguably captures an exogenous shock to misvaluation.<sup>15</sup> More importantly, our article differs from this previous work by focusing on the effects on innovative inputs, outputs, and inventiveness.

### III. Results

Our tests are based on MFFLOW as the misvaluation measure. Results using VP as an alternative proxy for misvaluation reinforce our conclusions (see the Supplementary Material).

#### A. Relation Between Misvaluation and Innovation Measures

We report the regression test results in Table 3 for the relation between year  $t + 1$  innovative inputs and outputs, with year  $t$  misvaluation. The dependent variables are the measures of R&D expenditures (RD), patents ( $\log(1 + \text{PAT})$ ), citations ( $\log(1 + \text{CITES})$ ), and inventiveness (NOVELTY, ORIGINALITY, and SCOPE). The independent variable of primary interest is misvaluation (beginning-of-year 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 (LEV), firm age truncated at 50 (AGE), and log of lagged assets. We report results using GS as the growth control; results are robust to using BP.

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of future earnings,  $V$  reflects the future-profit-creation side of R&D expenditures, not just the expense side.

<sup>14</sup>Morck et al. (1990) use capital asset pricing model (CAPM) alpha as their misvaluation proxy and find that it is unrelated to capital expenditures. Gilchrist et al. (2005) use dispersion in analyst forecasts of earnings as their misvaluation proxy to test for a relation with aggregate capital expenditures. Two studies use mutual fund fire sales as proxies for undervaluation and find that it is associated with cuts in capital expenditures (Hau and Lai (2013)) or R&D (Parise (2013)). Baker et al. (2003) examine the relation between financial constraints and valuations in determining capital expenditures. Several studies use structural methods to identify misvaluation effects on capital expenditures, with mixed conclusions (Chirinko and Schaller (2001), (2012), Campello and Graham (2013), Alti and Tetlock (2014), and Warusawitharana and Whited (2016)).

<sup>15</sup>Alternatively, it can be informative to use a more inclusive measure of misvaluation such as VP, as in our robustness checks, because VP 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.

TABLE 3  
Regressions of Investments and Innovative Output on Stock Misvaluation

All independent variables in Table 3 are standardized to have a mean of 0 and standard deviation of 1. All regressions include 2-digit Standard Industrial Classification (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. nonfinancial, nonutility firms listed on the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and National Association of Securities Dealers Automated Quotations (NASDAQ) with Compustat and CDA/Spectrum mutual fund flows data during 1981–2012. The patent and citation data (PAT, CITES, NOVELTY, ORIGINALITY, and SCOPE) sample period is 1981–2008. The variables are defined in Table 1.

Variable	RD	log(1 + PAT)	log(1 + CITES)	NOVELTY	ORIGINALITY	SCOPE
MFFLOW	-1.51 (-7.77)	-0.08 (-7.10)	-0.04 (-7.88)	-3.82 (-7.49)	-1.33 (-6.69)	-1.44 (-7.67)
GS	1.15 (6.43)	0.02 (3.43)	0.02 (4.35)	3.14 (5.40)	0.74 (4.67)	0.67 (4.64)
CF	1.07 (4.11)	0.13 (8.73)	0.06 (9.23)	5.53 (7.14)	1.76 (7.32)	1.83 (6.21)
LEV	-0.97 (-6.51)	-0.17 (-11.65)	-0.07 (-11.79)	-6.55 (-10.10)	-2.50 (-10.39)	-2.48 (-9.82)
log(AGE)	-1.64 (-8.07)	0.15 (5.26)	0.05 (4.48)	0.45 (0.46)	1.54 (3.53)	1.43 (3.67)
log(ASSETS)	-3.36 (-13.03)	0.65 (18.16)	0.23 (18.92)	12.80 (15.32)	5.69 (19.53)	4.61 (10.06)
Intercept	8.05 (54.22)	-0.18 (-8.20)	-0.09 (-9.73)	-0.67 (-0.76)	2.21 (7.33)	-4.73 (-8.31)
<i>N</i>	35,911	47,986	46,802	46,802	47,917	46,802
<i>R</i> <sup>2</sup>	0.2838	0.3850	0.3552	0.1252	0.1808	0.2260

All independent variables (except the indicator variables) are standardized to have a mean of 0 and standard deviation of 1. Following the innovation literature (e.g., Phillips and Zhdanov (2013), Seru (2014), Tian and Wang (2014), and Acharya and Xu (2017)), we control for year and industry fixed effects using the 2-digit SIC industry classification of Moskowitz and Grinblatt (1999). All standard errors in the regressions are simultaneously clustered by both firm and year.

### 1. Innovative Input

Column 1 of Table 3 describes the relation between misvaluation and R&D. It reports a highly significant negative coefficient of  $-1.51$  ( $t = -7.77$ ). Because high MFFLOW indicates equity undervaluation, this finding indicates that greater overvaluation (or less undervaluation) is strongly associated with higher innovative expenditures. A 1-standard-deviation increase in overvaluation is associated with a 16.8% increase in R&D relative to the R&D sample mean (9%). The effect of misvaluation on R&D is roughly comparable to the effect of a 1-standard-deviation increase in growth prospects (proxied by GS) and is far stronger than the effect of a 1-standard-deviation increase in cash flow.

A possible concern for tests of whether or how misvaluation affects innovative activities such as R&D is reverse causality: Investors may overvalue firms with high innovation activity. Two considerations help alleviate this concern. First, MFFLOW is a shock that is arguably exogenous to the firm's innovative project opportunities. It is based on investor outflows from mutual funds and is not based on whether a mutual fund is specifically selling the given firm. (As a reminder, MFFLOW is based on the hypothetical selling of a given firm that a fund would



engage in if it were to sell its current holdings in proportion to current weights in the firm's portfolio.)

Second, there is no evidence in the literature that suggests investors systematically overvalue R&D. To the contrary, because R&D is expensed, it is 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)).

## 2. Innovative Output Measures

We next examine innovative output measures:  $\log(1 + \text{PAT})$  measures the firm's success in obtaining patents, and  $\log(1 + \text{CITES})$  indirectly reflects the number and importance of the patents. The regressions again indicate significant misvaluation effects on innovative output and with alternative controls for growth prospects, suggesting an increase in innovative output that is commensurate with the increased innovative input associated with stock overvaluation. A 1-standard-deviation increase in overvaluation leads to a 0.08 increase in  $\log(1 + \text{PAT})$ , which boosts the patent count by 1.15, to 13.93, for a firm with a patent count at the sample mean. This is 9% of the sample mean number of patents, or a more than 20% increase over the sample median patent count of 5 for firms with a positive patent count.<sup>16</sup> A similar calculation suggests that for a firm with the mean CITES (11.59), a 1-standard-deviation increase in overvaluation leads to a 0.51 increase in the year and technology-class-adjusted citation count, which is 4.4% of the sample mean.

Turning to innovative inventiveness, we observe that greater overvaluation is also associated with all three proxies for inventiveness. A 1-standard-deviation increase in overvaluation leads to increases of 9.8%, 7.8%, and 9.6% 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. Robustness

The tests in Table 3 are designed to remove the effects of growth opportunities as much as possible to focus on misvaluation effects. Our measure of misvaluation (MFFLOW) is designed to be exogenous to growth opportunities, but our results are robust to including additional growth controls such as BP, GS, or analyst long-term earnings growth rate forecast (LTG; results using LTG as a control are not reported for brevity). Also, as mentioned in footnote 4, we use an industry-adjusted MFFLOW measure to remove any possible remaining industry growth effects from MFFLOW. Alternatively, we filter growth-related return factors from MFFLOW by using the residual from regressing MFFLOW on the Fama–French high-minus-low (book-to-market) factor or a high-minus-low R&D factor. Finally, to address the concern that firms acquire innovation through takeovers, we remove all firms

<sup>16</sup>For a firm with the mean patent count (12.78), a 1-standard-deviation decrease in MFFLOW leads to a new PAT value  $N$ , where  $\log(1 + N) - \log(1 + 12.78) = 0.08$ . Solving for  $N$  yields the new patent count of 13.93, which is an increase of 9% relative to the sample mean.

involved in acquisition activities in the prior 3 years. Again, all of our results remain robust.

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 0. In unreported tests, we find that our findings are robust to setting missing R&D values to 0 (MFFLOW still significantly affects R&D, though the effects are slightly weaker) or to restricting the sample to non-0 R&D observations (where the misvaluation effects on R&D and innovative output 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 the later years of our sample, there is a more severe truncation bias in the measurement of citations and inventiveness. In unreported tests, we split the sample into 2 roughly equal periods (before and after Dec. 1994). Most of the misvaluation effects on R&D, innovative output, and inventiveness are significant in the earlier period, and all are highly significant in the later period. The strength of the effects in the later period is more than double that in the earlier period. The stronger misvaluation effects on innovation may be related to greater importance of corporate innovation, increased use of equity financing, increased catering incentives of managers, or heightened shared sentiment effects, in more recent times.

## B. Long-Term Effects of Overvaluation on Innovation

It may take time for the investment in innovation to generate output, especially relatively fundamental innovations such as moon shot projects. However, 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. Therefore, 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 Table 3 using lagged misvaluation (MFFLOW) by 1, 2, or 3 years. Table 4 reports the results when we lag misvaluation by 3 years; results using shorter lags follow a similar pattern. Although the misvaluation effect on RD moderately decreases moving from the immediate next year to 3 years after, misvaluation significantly predicts future innovative output (PAT and CITES) and inventiveness (NOVELTY, ORIGINALITY, and SCOPE) up to 3 years ahead, with even a slightly higher strength (for most output and inventiveness measures) than the immediate effect, possibly because of lags in the effect of misvaluation on innovative output. 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 addresses how transient variations in stock prices motivate managers who care about short-term prices to take action that affects 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 Wurgler (2002) on valuation and capital structure). In addition, the financing channel is

TABLE 4  
 Long-Term Misvaluation Effects: Regressions of Innovative Input, Output,  
 and Inventiveness on 3-Year Lagged Stock Misvaluation

The misvaluation measure (MFFLOW) in Table 4 is lagged by 3 years. All independent variables are standardized to have a mean of 0 and standard deviation of 1. NOVELTY, ORIGINALITY, and SCOPE are in percentage. All regressions include 2-digit Standard Industrial Classification (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. nonfinancial, nonutility firms listed on the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and National Association of Securities Dealers Automated Quotations (NASDAQ) with Compustat and CDA/Spectrum mutual fund flows data during 1981–2012. The patent and citation data (PAT, CITES, NOVELTY, ORIGINALITY, and SCOPE) sample period is 1981–2008. The variables are defined in Table 1.

Variable	RD	log(1 + PAT)	log(1 + CITES)	NOVELTY	ORIGINALITY	SCOPE
MFFLOW	−1.42 (−7.08)	−0.09 (−6.17)	−0.04 (−6.61)	−4.27 (−6.25)	−1.53 (−7.08)	−1.23 (−4.85)
GS	1.83 (5.78)	−0.01 (−0.85)	0.00 (0.27)	2.03 (1.85)	0.56 (1.82)	0.39 (1.36)
CF	1.01 (3.32)	0.16 (7.62)	0.07 (7.92)	6.29 (6.17)	2.21 (6.56)	2.20 (5.44)
LEV	−0.80 (−4.77)	−0.17 (−10.08)	−0.07 (−9.93)	−5.86 (−8.00)	−2.21 (−8.22)	−2.13 (−7.92)
log(AGE)	−1.93 (−8.67)	0.17 (4.49)	0.05 (3.62)	−0.85 (−0.69)	1.44 (2.57)	1.15 (2.33)
log(ASSETS)	−3.28 (−12.07)	0.68 (17.20)	0.24 (17.94)	13.08 (15.23)	5.89 (18.52)	4.52 (9.31)
Intercept	8.51 (48.02)	−0.29 (−8.95)	−0.13 (−9.58)	−1.21 (−1.21)	1.78 (4.57)	−5.17 (−7.11)
<i>N</i>	28,147	36,089	35,058	35,058	36,034	35,058
<i>R</i> <sup>2</sup>	0.2831	0.4009	0.3762	0.1385	0.1909	0.2517

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)).

It could be argued that for misvaluation to affect innovation, it must persist long enough for firms to react to it. We provide some evidence in the Supplementary Material to suggest that misvaluation is not too transient for firms to use it when making innovation decisions.<sup>17</sup> To see whether the effect of MFFLOW on innovation is stronger when MFFLOW is more persistent, we conduct tests for subsamples sorted by MFFLOW autocorrelation. Specifically, we create an indicator for whether a firm is in the top autocorrelation quintile and interact it with 3-year lagged MFFLOW in the long-run innovation regression. Table 5 reports that this interaction variable has a negative and significant coefficient in most of the innovative output and inventiveness regressions, suggesting that MFFLOW has a stronger long-run effect on innovation when the misvaluation is more persistent. Interestingly, the interaction variable is insignificant when the

<sup>17</sup>MFFLOW, which is measured by summing quarterly outflows in the previous 4 quarters, has a mean autocorrelation of 0.254, indicating some persistence. Supplementary Material Table IA-12 provides evidence that misvaluation is sufficiently slow moving to affect firm innovative investment. It reports how MFFLOW evolves over time for the top and bottom MFFLOW quintiles, that is, the mean MFFLOW values for firms currently ranked in the top and bottom MFFLOW quintile over the past 5 years. Firms in the top quintile have higher MFFLOW in the past 5 years than do firms in the bottom quintile.

TABLE 5  
Persistence of Misvaluation and Long-Term Misvaluation Effects on Innovation

In Table 5, the 3-year lagged misvaluation measure (MFFLOW) is interacted with an indicator (HIAUTO) for the highest quintile of MFFLOW autocorrelation. The other variables are defined in Table 1. All independent variables are standardized to have a mean of 0 and standard deviation of 1. NOVELTY, ORIGINALITY, and SCOPE are in percentage. All regressions include 2-digit Standard Industrial Classification (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. nonfinancial, nonutility firms listed on the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and National Association of Securities Dealers Automated Quotations (NASDAQ) with Compustat and CDA/Spectrum mutual fund flows data during 1981–2012. The patent and citation data (PAT, CITES, NOVELTY, ORIGINALITY, and SCOPE) sample period is 1976–2008.

	RD	log(1+PAT)	log(1+CITES)	NOVELTY	ORIGINALITY	SCOPE
MFFLOW	-1.40 (-7.13)	-0.08 (-5.89)	-0.04 (-6.48)	-3.94 (-6.06)	-1.30 (-6.67)	-1.14 (-5.00)
MFFLOW × HIAUTO	-0.18 (-0.70)	-0.09 (-2.61)	-0.03 (-2.63)	-2.62 (-1.95)	-1.75 (-2.57)	-0.71 (-1.30)
GS	1.83 (5.78)	-0.01 (-0.85)	0.00 (0.28)	2.04 (1.86)	0.56 (1.82)	0.39 (1.36)
CF	1.01 (3.32)	0.16 (7.57)	0.07 (7.88)	6.27 (6.14)	2.19 (6.50)	2.19 (5.43)
LEV	-0.80 (-4.77)	-0.17 (-10.05)	-0.07 (-9.90)	-5.84 (-7.98)	-2.20 (-8.18)	-2.13 (-7.93)
log(AGE)	-1.92 (-8.66)	0.17 (4.53)	0.05 (3.66)	-0.81 (-0.66)	1.46 (2.62)	1.16 (2.36)
log(ASSETS)	-3.28 (-12.07)	0.68 (17.20)	0.24 (17.93)	13.08 (15.24)	5.89 (18.57)	4.52 (9.31)
Intercept	8.51 (47.73)	-0.29 (-9.01)	-0.13 (-9.63)	-1.28 (-1.27)	1.74 (4.45)	-5.19 (-7.08)
<i>N</i>	28,147	36,089	35,058	35,058	36,034	35,058
<i>R</i> <sup>2</sup>	0.2831	0.4013	0.3766	0.1386	0.1914	0.2518

dependent variable is innovative input (R&D). One possible interpretation of these results is that overvaluation promotes R&D spending regardless of whether mispricing is persistent, but when mispricing is persistent, firms tend to engage in more productive and inventive innovation.

### C. Financing Versus Nonfinancing Channels

Misvaluation can affect investment in general, either through equity issuance or risky debt issuance, or through catering or shared sentiment (Stein (1996), Baker et al. (2003), Gilchrist et al. (2005), Jensen (2005), Polk and Sapienza (2009), and Badertscher et al. (2019)). To estimate the extent to which misvaluation affects investment via the equity and debt channels, we perform a path analysis following Badertscher et al. (2019). Path analysis is a method of comparing an independent variable's direct effect on the dependent variable to the indirect effects that operate through intermediate variables. Of course, the ability to disentangle paths of effects relies on a test variable such as MFFLOW to identify causation. We estimate the following regressions:

$$RD_{it} = a_1 + b_1 MFFLOW_{it} + c_1 EI_{it} + d_1 DI_{it} + \theta_1 X_{1it} + u_{1it},$$

$$EI_{it} = a_2 + b_2 MFFLOW_{it} + \theta_2 X_{2it} + u_{2it},$$

$$DI_{it} = a_3 + b_3 MFFLOW_{it} + \theta_3 X_{3it} + u_{3it},$$

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  $X_1$  and  $X_2$  (such as GS, CF or ROA, LEV, AGE, and ASSETS), with standard errors clustered by firm and year.

Panels A and B of Table 6 report the control variables for each regression. The estimated value of  $b_1$  captures the nonfinancing effect of MFFLOW on investment, and the estimated value of  $b_2 \times c_1$  captures the effect of MFFLOW through the equity issuance channel. Similarly, the estimated value of  $b_3 \times d_1$  captures the effect of MFFLOW through the debt issuance channel. We interpret the nonfinancing 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. A similar remark applies to debt issuance.

Firm overvaluation (as measured by equity overvaluation) can lead to a reduction in both the cost of equity financing and cost of debt financing. There are, however, some reasons to expect the effect on debt financing to be relatively weak. As documented in Dong et al. (2012), debt issuance is not nearly as sensitive as equity issuance to equity misvaluation. On one hand, the factors that drive high equity valuation may similarly drive high debt valuation, which reduces the cost of debt and therefore increases the incentive to issue debt. On the other hand, there is a substitution effect between equity and debt financing, and because equity is more sensitive to equity valuation than debt, an increased level of equity financing may lead to a reduction in debt financing. Therefore, the net effect of equity misvaluation on debt issuance should be weak or perhaps even reversed.

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 occurs through the equity issuance, debt issuance, and nonfinancing channels. The preponderance of the total effect of MFFLOW on R&D, 72.12%, comes from the nonfinancing channel. The equity channel contributes 27.06%, with debt issuance contributing the remaining 0.82%. Additional tests (reported in Supplementary Material Table IA-4) confirm that using VP instead of MFFLOW to measure mispricing, we obtain the same conclusion that nonfinancing is the primary channel through which stock misvaluation affects R&D spending.

According to the pecking order theory, debt issuance is preferred to equity financing. Our finding that equity issuance is more important than debt financing in innovative investment is therefore inconsistent with the pecking order. Other research also finds evidence inconsistent with the pecking order (e.g., Graham and Harvey (2001)). One interpretation of our finding is that the existence of equity overvaluation in effect reduces the cost of equity, which consists of the main form of external financing associated with innovation. We should expect this reduction to be especially important for firms that engage in R&D activity, as equity is the main form of external financing for firms that engage in R&D. This is also consistent with the evidence from Huang and Ritter (2019) that debt financing is associated with

TABLE 6  
Path Analysis of the Effects of Misvaluation on R&D

The analysis in Table 6 is based on a sample during 1981–2012. ROA is operating income before depreciation and research and development (R&D) expenses scaled by total assets for the prior fiscal year, and  $\Delta CR$  is change in the current ratio (total current assets divided by total current liabilities). All other variables are defined in Table 1. 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 break the total effect of MFFLOW on R&D into three parts: the direct catering effect, and the indirect effects through the equity issuance and debt issuance channels.

Panel A. RD Regression		Panel B. EI and DI Regressions		
Variable	RD	Variable	EI	DI
MFFLOW	-18.4757 (-6.30)	MFFLOW	-46.2833 (-9.91)	-8.7069 (-5.54)
EI	0.1498 (16.12)	GS	1.0165 (7.56)	0.5847 (6.94)
DI	0.0240 (3.55)	ROA	-0.3178 (-9.61)	0.0487 (5.20)
GS	0.2926 (4.57)	$\Delta CR$	3.8549 (5.03)	-1.6203 (-8.58)
CF	0.1085 (9.13)	LEV	-0.3374 (-0.23)	-4.3868 (-5.66)
LEV	-4.1511 (-8.06)	log(AGE)	-2.0671 (-6.30)	-1.1200 (-5.64)
log(AGE)	-1.2128 (-7.48)	log(ASSETS)	-2.6969 (-13.15)	0.1615 (1.58)
log(ASSETS)	-1.2091 (-11.32)	Intercept	34.5739 (15.15)	8.3476 (14.12)
Intercept	16.3468 (21.60)			
<i>N</i>	35,876	<i>N</i>	55,320	55,405
<i>R</i> <sup>2</sup>	0.4476	<i>R</i> <sup>2</sup>	0.1488	0.0428
Panel C. Path Analysis Results for the Effects of MFFLOW on RD				
Path	Coefficient	<i>t</i> -Stat.		
(1) Direct effect of MFFLOW on RD MFFLOW → RD	-18.4757	(-6.30)		
(2) Indirect effect of MFFLOW on RD via equity channel MFFLOW → EI EI → RD Equity path effect	-46.2833 0.1498 -6.9332	(-9.91) (16.12)		
(3) Indirect effect of MFFLOW on RD via debt channel MFFLOW → DI DI → RD Debt path effect	-8.7069 0.0240 -0.2090	(-5.54) (3.55)		
(4) Total MFFLOW effect on RD % Direct path % Equity path % Debt path	-25.6179 72.12% 27.06% 0.82%			

short-term cash needs whereas equity financing is associated with long-term R&D investment.

We also perform a path analysis for subsamples sorted by yearly aggregate misvaluation (measured by the mean MFFLOW of the sample firms) and catering incentive (proxied by share turnover). Supplementary Material Tables IA-13 and IA-14 show that the total MFFLOW effect on R&D, as well as the effect through each channel, is much higher in high-valuation years (i.e., below-median aggregate MFFLOW) than in low-valuation markets. In fact, the direct effect accounts for a larger portion of the total effect in high-valuation markets (77.3%) than in low-valuation markets (71.1%). Likewise, Tables IA-15 and IA-16 confirm that the total



TABLE 7  
 Regressions of Innovative Input, Output and Inventiveness  
 on Stock Misvaluation: Interaction with Turnover

In Table 7, the misvaluation measure (MFFLOW) is interacted with an overvaluation indicator for the highest turnover quintile (HITURN). All other variables are defined in Table 1. All independent variables are standardized to have a mean of 0 and standard deviation of 1. NOVELTY, ORIGINALITY, and SCOPE are in percentage. All regressions include 2-digit Standard Industrial Classification (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. nonfinancial, nonutility firms listed on the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and National Association of Securities Dealers Automated Quotations (NASDAQ) with Compustat and CDA/Spectrum mutual fund flows data during 1981–2012. The patent and citation data (PAT, CITES, NOVELTY, ORIGINALITY, and SCOPE) sample period is 1976–2008.

Variable	RD	log(1 + PAT)	log(1 + CITES)	NOVELTY	ORIGINALITY	SCOPE
MFFLOW	-1.25 (-7.44)	-0.06 (-6.52)	-0.03 (-7.39)	-2.79 (-6.39)	-1.07 (-6.23)	-1.15 (-7.30)
MFFLOW × HITURN	-1.43 (-2.73)	-0.25 (-5.21)	-0.10 (-4.91)	-7.88 (-4.45)	-2.53 (-4.60)	-3.06 (-3.98)
GS	1.03 (5.90)	0.02 (2.35)	0.01 (3.29)	2.56 (4.72)	0.61 (3.90)	0.53 (3.82)
CF	1.01 (4.07)	0.13 (8.90)	0.06 (9.39)	5.26 (7.02)	1.70 (7.18)	1.77 (6.32)
LEV	-0.94 (-6.89)	-0.17 (-11.60)	-0.07 (-11.84)	-6.34 (-10.37)	-2.45 (-10.67)	-2.42 (-10.11)
log(AGE)	-1.39 (-6.61)	0.16 (5.67)	0.06 (5.00)	1.22 (1.23)	1.71 (3.88)	1.61 (4.11)
log(ASSETS)	-3.79 (-13.43)	0.63 (18.07)	0.22 (18.64)	11.33 (12.25)	5.36 (16.71)	4.28 (9.78)
TURNOVER	1.05 (4.14)	0.03 (1.06)	0.02 (1.88)	3.99 (3.84)	0.84 (2.35)	0.80 (2.18)
Intercept	7.59 (43.23)	-0.22 (-5.75)	-0.12 (-7.18)	-5.14 (-3.46)	1.24 (2.32)	-5.70 (-7.06)
<i>N</i>	35,911	47,986	46,802	46,802	47,917	46,802
<i>R</i> <sup>2</sup>	0.2919	0.3878	0.3589	0.1293	0.1828	0.2286

effect, as well as component effects, of MFFLOW on R&D is much higher among high-turnover firms. However, the equity channel effect is also stronger among high-turnover firms, so that overall, the portion of effect through the direct channel is slightly lower for high-turnover firms (73.9%) than for low-turnover firms (74.7%).

## D. Effect of Turnover

Table 7 tests for interaction effects of overvaluation and catering incentives on innovative investments and output. We test the hypothesis that misvaluation has a stronger marginal effect on innovation among high-turnover firms by including an interaction between MFFLOW and an indicator for whether a firm is in the top turnover quintile.

Consistent with the hypothesis that misvaluation effects on innovation are stronger when firms have a strong catering incentive, the sensitivity of R&D expenditures to MFFLOW is much stronger among high-turnover firms, with an interaction coefficient of  $-1.43$  ( $t = -2.73$ ), which is larger than the baseline coefficient of  $-1.25$  ( $t = -7.44$ ). An even stronger pattern holds for innovative output and inventiveness. In the top turnover quintile, the effect of overvaluation on innovative output (PAT and CITES) is 3.9–5.2 times greater, and the effect on

inventiveness (NOVELTY, ORIGINALITY, and SCOPE) is 3.4–3.8 times greater, than the baseline effect.

In the full sample, a 1-standard-deviation increase in overvaluation as measured by MFFLOW leads to an increase of 16.8% in R&D, 9% in PAT, 4.4% in CITES, 9.8% in NOVELTY, 7.8% in ORIGINALITY, and 9.6% in SCOPE relative to the sample mean values. However, the effects are much stronger in the top turnover quintile. According to the coefficient estimates in Table 6, among the top turnover quintile, a 1-standard-deviation boosts RD, PAT, CITES, NOVELTY, ORIGINALITY, and SCOPE by 29.8%, 39.2%, 15.1%, 27.4%, 21.2%, and 28.1% relative to the sample mean, respectively. The results confirm that the sensitivity of R&D, patents, and citations to overvaluation is greater in the top turnover quintile. Furthermore, the sensitivity of innovative novelty, originality, and scope to overvaluation is also much stronger among high-turnover firms, consistent with catering taking the form of undertaking moon shot projects.<sup>18</sup>

### E. Convexity of Overvaluation Effects

Are the misvaluation effects on innovation stronger among overvalued or undervalued firms? On one hand, it is easier to cut than to increase innovation, which implies stronger effects when firms are undervalued. On the other hand, there are several economic reasons to believe that the misvaluation effect on innovation is stronger among overvalued than undervalued firms. First, when there are fixed costs of issuing equity, overvalued firms should be more likely to issue than undervalued firms. Second, when there are positive complementarities in innovation, overvaluation tends to have a nonlinear increasing effect on innovation. Third, overvaluation can insulate managers from career concerns if such overvaluation is associated with favorable assessment of managerial skill. Such overvaluation can therefore encourage managers to undertake risky innovative projects. Therefore, the direction of nonlinearity is an empirical question.

Table 8 tests for nonlinear effects of overvaluation on innovative investments and output. We test the nonlinear effect of misvaluation by including an interaction between MFFLOW and an indicator for a firm being in the bottom MFFLOW (top overvaluation) quintile. Consistent with the hypothesis that misvaluation effects on innovation are convex, the sensitivity of R&D expenditures to MFFLOW is much stronger among overvalued firms, with a large interaction coefficient of  $-5.39$  ( $t = -9.42$ ), which is nearly 5 times larger than the baseline coefficient of  $-1.18$  ( $t = -7.78$ ). 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 6.7–8.7 times greater, and the effect on inventiveness (NOVELTY, ORIGINALITY, and SCOPE) is 4.4–6.3 times greater, than the baseline effect.

This nonlinear effect of misvaluation continues to hold when we use VP to measure misvaluation (Supplementary Material Table IA-10). When we repeat the test using turnover-orthogonalized fund flow (MFF\_R) to measure misvaluation,

<sup>18</sup>In unreported tests we find that the effects of MFFLOW on innovation are generally stronger among firms with the least financial constraints (i.e., with the lowest Kaplan–Zingales (1997) index), confirming that MFFLOW affects innovation through the nonfinancing channel.

TABLE 8  
 Regressions of Innovative Input, Output, and Inventiveness on  
 Stock Misvaluation: Interaction with High Valuation Indicator

The misvaluation measure (MFFLOW) in Table 8 is interacted with an overvaluation indicator for the lowest MFFLOW quintile (LOFLOW). All other variables are defined in Table 1. All independent variables are standardized to have a mean of 0 and standard deviation of 1. NOVELTY, ORIGINALITY, and SCOPE are in percentage. All regressions include 2-digit Standard Industrial Classification (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. nonfinancial, nonutility firms listed on the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and National Association of Securities Dealers Automated Quotations (NASDAQ) with Compustat and CDA/Spectrum mutual fund flows data during 1981–2012. The patent and citation data (PAT, CITES, NOVELTY, ORIGINALITY, and SCOPE) sample period is 1976–2008.

Variable	RD	log(1 + PAT)	log(1 + CITES)	NOVELTY	ORIGINALITY	SCOPE
MFFLOW	-1.18 (-7.78)	-0.06 (-7.15)	-0.03 (-8.05)	-3.09 (-6.65)	-1.11 (-6.75)	-1.11 (-8.11)
MFFLOW × LOFLOW	-5.39 (-9.42)	-0.46 (-7.09)	-0.17 (-7.44)	-12.71 (-4.42)	-3.82 (-3.89)	-5.83 (-7.59)
GS	1.10 (6.22)	0.02 (2.90)	0.01 (4.01)	3.00 (5.36)	0.70 (4.53)	0.61 (4.31)
CF	1.17 (4.58)	0.14 (9.67)	0.06 (9.99)	5.71 (7.45)	1.82 (7.71)	1.92 (6.64)
LEV	-1.01 (-6.87)	-0.17 (-11.73)	-0.07 (-11.91)	-6.63 (-10.14)	-2.53 (-10.38)	-2.51 (-10.02)
log(AGE)	-1.60 (-7.80)	0.15 (5.45)	0.05 (4.65)	0.54 (0.54)	1.56 (3.59)	1.47 (3.81)
log(ASSETS)	-3.07 (-13.15)	0.67 (18.89)	0.24 (19.99)	13.37 (16.21)	5.87 (19.77)	4.88 (10.94)
Intercept	7.72 (46.22)	-0.20 (-9.35)	-0.10 (-10.85)	-1.30 (-1.46)	2.02 (6.46)	-5.03 (-8.79)
<i>N</i>	35,911	47,986	46,802	46,802	47,917	46,802
<i>R</i> <sup>2</sup>	0.2909	0.3892	0.3586	0.1263	0.1817	0.2283

the convexity result does not hold (Tables IA-11 and IA-12). However, MFF\_R is overly restrictive as we describe in Section I because it removes all effects of turnover, a valid source of misvaluation, from the MFFLOW measure. Therefore, we infer overall that the misvaluation effect on innovation is convex.

## F. Quantile Regressions

Our results so far are based on least squares regressions. We run quantile regressions, which are more robust to the influences of outliers and distributional assumptions of the error process than linear regressions, to provide further robustness of our findings.<sup>19</sup> Our purpose is to explore whether overvaluation has an especially strong effect in promoting unusually high innovative input, output, and inventiveness. For RD, 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, because the median is 0, we choose quantile values of 0.65, 0.7, 0.75, and 0.8. If overvaluation promotes unusually high levels of innovative input, output, or inventiveness, we expect to see stronger overvaluation effects at higher quantiles.

<sup>19</sup>The quantile regression parameter estimates the change in a specified quantile (*Q*) of the response variable produced by a 1-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 different quantiles.

TABLE 9  
Quantile Regressions

In Table 9 we perform quantile regressions of research and development (RD), innovative output (PAT and CITES), and inventiveness (NOVELTY, ORIGINALITY, and SCOPE) variables on misvaluation (measured by MFFLOW) 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 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 0. We report only the coefficient on MFFLOW. *t*-statistics of the 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 reported in square brackets. The variables are defined in Table 1.

Variable	Q(0.2)	Q(0.4)	Q(0.6)	Q(0.8)	Q(0.8)-Q(0.2) [ <i>p</i> -value]
RD	-0.103 (-11.74)	-0.497 (-20.61)	-0.923 (-22.08)	-1.427 (-19.70)	-1.324 [0.000]
Variable	Q(0.65)	Q(0.7)	Q(0.75)	Q(0.8)	Q(0.8)-Q(0.65) [ <i>p</i> -value]
PAT	-0.067 (-10.98)	-0.078 (-9.26)	-0.089 (-9.89)	-0.100 (-9.81)	-0.032 [0.000]
CITES	-0.033 (-11.59)	-0.037 (-10.26)	-0.041 (-11.30)	-0.051 (-12.31)	-0.018 [0.000]
NOVELTY	-1.509 (-8.36)	-2.146 (-7.62)	-3.202 (-7.70)	-4.278 (-7.49)	-2.769 [0.000]
ORIGINALITY	-0.113 (-6.89)	-0.605 (-6.48)	-1.469 (-6.47)	-2.089 (-7.15)	-1.976 [0.000]
SCOPE	-0.676 (-11.11)	-1.290 (-12.32)	-2.018 (-14.54)	-2.345 (-15.52)	-1.669 [0.000]

The results are reported in Table 9. For brevity, we report only the coefficients of the misvaluation proxy (MFFLOW). If overvaluation is especially important in driving the highest R&D outcomes and innovative outputs (moon shots), we ought to observe stronger MFFLOW effects for higher quantile cutoffs. This is indeed what we observe. For example, for R&D, although the quantile regressions show a statistically significant effect of MFFLOW at all quantiles, the effect of MFFLOW increases from -0.103 at quantile 0.2 to -1.427 at quantile 0.8, with the difference in MFFLOW coefficients highly significant.

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. 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.

#### IV. Conclusion

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

We use a proxy for equity misvaluation that is designed to focus on variations in mispricing unrelated to the firm's growth prospects. This misvaluation measure uses hypothetical mutual fund outflows, like the fund flow measure of Edmans et al. (2012), but is unrelated to contemporaneous returns. Extensive additional controls

for growth opportunities are included as a failsafe. We verify that our results are robust to using a very different proxies for misvaluation based on a price-to-fundamentals ratio.

The tests reveal a strong positive association between equity overvaluation and subsequent R&D spending, patent and patent citation production, and inventiveness. Furthermore, 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.

The effect of misvaluation operates partly via the association of misvaluation with equity issuance, and more strongly via the nonfinancing 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. The sensitivity of innovative inventiveness to misvaluation is greater among high-turnover firms, consistent with catering or shared sentiment effects, especially in the form of taking more inventive projects. Furthermore, our evidence suggests that the effect of misvaluation on innovation is nonlinear, with stronger effects among the most overvalued firms.

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

## Appendix. Calculation of MFFLOW

We follow Edmans et al. (2012) to calculate the hypothetical mutual fund outflow price pressure measure (MFFLOW), with one modification. 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

$$\text{OUTFLOW}_{j,t} = \frac{\text{TA}_{j,t-1}(1 + R_{j,t}) - \text{TA}_{j,t}}{\text{TA}_{j,t-1}},$$

where  $\text{TA}_{j,t}$  is the total asset value of fund  $j$  ( $= 1, \dots, m$ ) 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.  $\text{OUTFLOW}_{j,t}$  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 U.S. 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

$$\text{SHARE}_{i,j,t} \times \text{PRC}_{i,t},$$

where  $\text{SHARE}_{i,j,t}$  is the number of stocks  $i$  held by fund  $j$  at the end of quarter  $t$ , and  $\text{PRC}_{i,t}$  is the price of stock  $i$  at the end of quarter  $t$ .

Third, we compute the quarterly mutual fund flow

$$\text{QMFFLOW}_{i,t} = \sum_{j=1}^m \frac{\text{OUTFLOW}_{j,t} \times \text{SHARE}_{i,j,t} \times \text{PRC}_{i,t}}{\text{VOL}_{i,t}},$$

where the summation is only over funds  $j$  for which  $\text{OUTFLOW}_{j,t} \geq 0.05$  and where  $\text{VOL}_{i,t}$  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 QMFFLOW across the 4 quarters up to quarter  $t$ .

Importantly, Wardlaw (2020) notes that the original Edmans et al. (2012) measure uses  $\text{PRC}_{i,t-1}$  in the preceding equation, which together with  $\text{VOL}_{i,t}$  in the denominator, induces a mechanical correlation between MFFLOW and contemporaneous returns. We use  $\text{PRC}_{i,t}$  and  $\text{VOL}_{i,t}$  measured in the same quarter, which removes the mechanical correlation, and so our MFFLOW measure is immune to this critique.

## Supplementary Material

To view supplementary material for this article, please visit <http://dx.doi.org/10.1017/S0022109020000666>.

## References

- Acharya, V., and Z. Xu. "Financial Dependence and Innovation: The Case of Public versus Private Firms." *Journal of Financial Economics*, 124 (2017), 223–243.
- Ali, U., and D. A. Hirshleifer. "Opportunism as a Managerial Trait: Predicting Insider Trading Profits and Misconduct." *Journal of Financial Economics*, 126 (2017), 490–515.
- Alti, A., and P. C. Tetlock. "Biased Beliefs, Asset Prices, and Investment: A Structural Approach." *Journal of Finance*, 69 (2014), 325–361.
- Badertscher, B.; D. Shanthikumar; and S. H. Teoh. "Private Firm Investment and Public Peer Misvaluation." *Accounting Review*, 94 (2019), 31–60.
- Baker, M.; X. Pan; and J. Wurgler. "A Reference Point Theory of Mergers and Acquisitions." *Journal of Financial Economics*, 106 (2012), 49–71.
- Baker, M., and J. C. Stein. "Market Liquidity as a Sentiment Indicator." *Journal of Financial Markets*, 7 (2004), 271–299.
- Baker, M.; J. C. Stein; and J. Wurgler. "When Does the Market Matter? Stock Prices and the Investment of Equity-Dependent Firms." *Quarterly Journal of Economics*, 118 (2003), 969–1005.
- Baker, M., and J. Wurgler. "The Equity Share in New Issues and Aggregate Stock Returns." *Journal of Finance*, 55 (2000), 2219–2257.
- Baker, M., and J. Wurgler. "Market Timing and Capital Structure." *Journal of Finance*, 57 (2002), 1–32.
- Barro, R. J. "The Stock Market and Investment." *Review of Financial Studies*, 3 (1990), 115–131.
- Basalla, G. *The Evolution of Technology*. Cambridge, UK: Cambridge University Press (1988).
- Birru, J. "Confusion of Confusions: A Test of the Disposition Effect and Momentum." *Review of Financial Studies*, 28 (2015), 1849–1873.
- Blanchard, O.; C. Rhee; and L. Summers. "The Stock Market, Profit, and Investment." *Quarterly Journal of Economics*, 108 (1993), 115–136.
- Camanho, N. "The Effects of Fund Flows on Corporate Investment: A Catering View." Working Paper, Católica Lisbon School of Business and Economics (2015).
- Campello, M., and J. R. Graham. "Do Stock Prices Influence Corporate Decisions? Evidence from the Technology Bubble." *Journal of Financial Economics*, 107 (2013), 89–110.
- Chan, L. K. C.; J. Lakonishok; and T. Sougiannis. "The Stock Market Valuation of Research and Development Expenditures." *Journal of Finance*, 56 (2001), 2431–2456.



- Chirinko, R. S., and H. Schaller. "Business Fixed Investment and 'Bubbles': The Japanese Case." *American Economic Review*, 91 (2001), 663–680.
- Chirinko, R. S., and H. Schaller. "Do Bubbles Lead to Overinvestment? A Revealed Preference Approach." In *New Perspectives on Asset Price Bubbles: Theory, Evidence, and Policy*, D. D. Evanoff, G. G. Kaufman, and A. G. Malliaris, eds. New York, NY: Oxford University Press, (2012), 433–453.
- Cornell, B. "The Tesla Run-Up: A Follow-Up with Investment Implications." *Journal of Portfolio Management*, 43 (2016), 1–4.
- Cornell, B., and A. Damodaran. "Tesla: Analysis of a Run-Up." *Journal of Portfolio Management*, 41 (2014), 139–151.
- Coval, J., and E. Stafford. "Asset Fire Sales (and Purchases) in Equity Markets." *Journal of Financial Economics*, 86 (2007), 479–512.
- Custodio, C.; M. A. Ferreira; and P. P. Matos. "Do General Managerial Skills Spur Innovation?" Working Paper, Darden Business School (2013).
- DeAngelo, H.; L. DeAngelo; and R. M. Stulz. "Seasoned Equity Offerings, Market Timing, and the Corporate Lifecycle." *Journal of Financial Economics*, 95 (2010), 275–295.
- Dessaint, O.; T. Foucault; L. Fresard; and A. Matray. "Noisy Stock Prices and Corporate Investment." *Review of Financial Studies*, 32 (2019), 2625–2672.
- D'Mello, R., and P. K. Shroff. "Equity Undervaluation and Decisions Related to Repurchase Tender Offers: An Empirical Investigation." *Journal of Finance*, 55 (2000), 2399–2424.
- Dong, M.; D. A. Hirshleifer; S. Richardson; and S. H. Teoh. "Does Investor Misvaluation Drive the Takeover Market?" *Journal of Finance*, 61 (2006), 725–762.
- Dong, M.; D. A. Hirshleifer; and S. H. Teoh. "Overvalued Equity and Financing Decisions." *Review of Financial Studies*, 25 (2012), 3645–3683.
- Eberhart, A. C.; W. F. Maxwell; and A. R. Siddique. "An Examination of Long-Term Abnormal Stock Returns and Operating Performance Following R&D Increases." *Journal of Finance*, 59 (2004), 623–650.
- Edmans, A.; I. Goldstein; and W. Jiang. "The Real Effects of Financial Markets: The Impact of Prices on Takeovers." *Journal of Finance*, 67 (2012), 933–971.
- George, T. J.; C.-Y. Hwang; and Y. Li. "The 52-Week High, Q Theory and the Cross Section of Stock Returns." *Journal of Financial Economics*, 128 (2018), 148–163.
- Gilchrist, S.; C. P. Himmelberg; and G. Huberman. "Do Stock Price Bubbles Influence Corporate Investment?" *Journal of Monetary Economics*, 52 (2005), 805–827.
- Gornall, W., and I. Strebulaev. "Squaring Venture Capital Valuations with Reality." Working Paper, University of British Columbia and Stanford University (2017).
- Graham, J. R., and C. R. Harvey. "The Theory and Practice of Corporate Finance: Evidence from the Field." *Journal of Financial Economics*, 61 (2001), 187–243.
- Gross, D. *Pop! Why Bubbles Are Great for the Economy*. New York, NY: HarperCollins (2009).
- Hall, B. H.; A. Jaffe; and M. Trajtenberg. "The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools." Working Paper 8498, National Bureau of Economic Research (2001).
- Hall, B. H.; A. Jaffe; and M. Trajtenberg. "Market Value and Patent Citations." *RAND Journal of Economics*, 36 (2005), 16–38.
- Hau, H., and S. Lai. "Real Effects of Stock Underpricing." *Journal of Financial Economics*, 108 (2013), 392–408.
- Henderson, B. J.; N. Jegadeesh; and M. S. Weisbach. "World Markets for Raising New Capital." *Journal of Financial Economics*, 82 (2006), 63–101.
- Hirshleifer, D. A.; P.-H. Hsu; and D. Li. "Innovative Originality, Profitability, and Stock Returns." *Review of Financial Studies*, 31 (2018), 2553–2605.
- Hirshleifer, D. A.; A. Low; and S. H. Teoh. "Are Overconfident CEOs Better Innovators?" *Journal of Finance*, 67 (2012), 1457–1498.
- Hirshleifer, D. A.; A. Subrahmanyam; and S. Titman. "Feedback and the Success of Irrational Investors." *Journal of Financial Economics*, 81 (2006), 311–338.
- Huang, R., and J. R. Ritter. "Corporate Cash Shortfalls and Financing Decisions." Working Paper, University of Florida (2019).
- Jeng, L. A.; A. Metrick; and R. Zeckhauser. "Estimating the Returns to Insider Trading: A Performance-Evaluation Perspective." *Review of Economics and Statistics*, 85 (2003), 453–471.
- Jensen, M. C. "Agency Costs of Overvalued Equity." *Financial Management*, 34 (2005), 5–19.
- Kaplan, S. N., and L. Zingales. "Do Financial Constraints Explain Why Investment Is Correlated with Cash Flow?" *Quarterly Journal of Economics*, 112 (1997), 169–216.
- Keynes, J. M. "An Economic Analysis of Unemployment." In *Collected Writings*, Vol. XIII. London, UK: Macmillan (1931), 343–367.

- Kogan, L.; D. Papanikolaou; A. Seru; and N. Stoffman. "Technological Innovation, Resource Allocation, and Growth." *Quarterly Journal of Economics*, 132 (2017), 665–712.
- Lakonishok, J., and I. Lee. "Are Insider Trades Informative?" *Review of Financial Studies*, 14 (2001), 79–111.
- LaPlante, M., and C. J. Muscarella. "Do Institutions Receive Comparable Execution in the NYSE and Nasdaq Markets? A Transaction Study of Block Trades." *Journal of Financial Economics*, 45 (1997), 97–134.
- Lee, C. M. C., and B. Swaminathan. "Price Momentum and Trading Volume." *Journal of Finance*, 55 (2000), 2017–2069.
- Lerner, J.; M. Sørensen; and P. Strömberg. "Private Equity and Long-Run Investment: The Case of Innovation." *Journal of Finance*, 66 (2011), 445–477.
- Lev, B., and T. Sougiannis. "The Capitalization, Amortization, and Value-Relevance of R&D." *Journal of Accounting and Economics*, 21 (1996), 107–138.
- Li, D. "Financial Constraints, R&D Investment, and Stock Returns." *Review of Financial Studies*, 24 (2011), 2974–3007.
- Li, J. "Fund Flows, Slow-Moving Liquidity Provision, and Common Factors in Stock Returns." Working Paper, Stanford University (2019).
- Li, J., and J. Yu. "Investor Attention, Psychological Anchors, and Stock Return Predictability." *Journal of Financial Economics*, 104 (2012), 401–419.
- Lou, X., and Y. A. Wang. "Flow-Induced Trading Pressure and Corporate Investment." *Journal of Financial and Quantitative Analysis*, 53 (2018), 171–201.
- Loughran, T., and J. Ritter. "The New Issues Puzzle." *Journal of Finance*, 50 (1995), 23–52.
- Ma, Y. "Non-Financial Firms as Cross-Market Arbitrageurs." *Journal of Finance*, 74 (2019), 3041–3087.
- Morck, R.; A. Shleifer; and R. W. Vishny. "The Stock Market and Investment: Is the Market a Sideshow?" *Brookings Papers on Economic Activity* (1990), 157–202.
- Moskowitz, T. J., and M. Grinblatt. "Do Industries Explain Momentum?" *Journal of Finance*, 54 (1999), 1249–1290.
- Ohlson, J. "Earnings, Book Values, and Dividends in Equity Valuation." *Contemporary Accounting Research*, 11 (1995), 661–687.
- Parise, G. "Do Underpriced Firms Innovate Less?" Working Paper, Swiss Finance Institute (2013).
- Phillips, G. M., and A. Zhdanov. "R&D and the Incentives from Merger and Acquisition Activity." *Review of Financial Studies*, 26 (2013), 34–78.
- Polk, C., and P. Sapienza. "The Stock Market and Corporate Investment: A Test of Catering Theory." *Review of Financial Studies*, 22 (2009), 187–217.
- Ritter, J. R. "The Long-Run Performance of Initial Public Offerings." *Journal of Finance*, 46 (1991), 3–27.
- Romer, P. M. "Endogenous Technological Change." *Journal of Political Economy*, 98 (1990), S71–S102.
- Schumpeter J. A. *The Theory of Economic Development*. Cambridge, MA: Harvard University Press (1934).
- Seru, A. "Firm Boundaries Matter: Evidence from Conglomerates and R&D Activity." *Journal of Financial Economics*, 111 (2014), 381–405.
- Shleifer, A., and R. W. Vishny. "Stock Market Driven Acquisitions." *Journal of Financial Economics*, 55 (2003), 2219–2258.
- Singh, J., and L. Fleming. "Lone Inventors as Sources of Breakthroughs: Myth or Reality?" *Management Science*, 56 (2010), 41–56.
- Sorkin, A. R. "How Valuable Is a Unicorn? Maybe Not as Much as It Claims to Be." *New York Times* (Oct. 16, 2017), available at <https://www.nytimes.com/2017/10/16/business/how-valuable-is-a-unicorn-maybe-not-as-much-as-it-claims-to-be.html>.
- Stein, J. "Rational Capital Budgeting in an Irrational World." *Journal of Business*, 69 (1996), 429–455.
- Teoh, S. H.; I. Welch; and T. J. Wong. "Earnings Management and the Long-Term Market Performance of Initial Public Offerings." *Journal of Finance*, 53 (1998a), 1935–1974.
- Teoh, S. H.; I. Welch; and T. J. Wong. "Earnings Management and the Underperformance of Seasoned Equity Offerings." *Journal of Financial Economics*, 50 (1998b), 63–99.
- Teoh, S. H.; T. J. Wong; and G. Rao. "Are Accruals during an Initial Public Offering Opportunistic?" *Review of Accounting Studies*, 3 (1998), 175–208.
- Tian, X., and T. Wang. "Tolerance for Failure and Corporate Innovation." *Review of Financial Studies*, 27 (2014), 211–255.
- Tobin, J. "A General Equilibrium Approach to Monetary Theory." *Journal of Money, Credit, and Banking*, 1 (1969), 15–29.
- Trajtenberg, M.; R. Henderson; and A. Jaffe. "University versus Corporate Patents: A Window on the Basicness of Invention." *Economics of Innovation and New Technology*, 5 (1997), 19–50.

- Wardlaw, M. "Measuring Mutual Fund Flow Pressure as Shock to Stock Returns." *Journal of Finance*, forthcoming (2020).
- Warusawitharana, M., and T. M. Whited. "Equity Market Misvaluation, Financing, and Investment." *Review of Financial Studies*, 29 (2016), 603–654.
- Weitzman, M. L. "Recombinant Growth." *Quarterly Journal of Economics*, 113 (1998), 331–360.
- Welch, I., and D. Wessels. "The Cross-Sectional Determinants of Corporate Capital Expenditures." *Schmalenbach Business Review*, 52 (2000), 103–136.