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Quantifying Managerial Ability: A New Measure and Validity Tests

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We propose a measure of managerial ability, based on managers' efficiency in generating revenues, which is available for a large sample of firms and outperforms existing ability measures. We find that our measure is strongly associated with manager fixed effects and that the stock price reactions to chief executive officer (CEO) turnovers are positive (negative) when we assess the outgoing CEO as low (high) ability. We also find that replacing CEOs with more (less) able CEOs is associated with improvements (declines) in subsequent firm performance. We conclude with a demonstration of the potential of the measure. We find that the negative relation between equity financing and future abnormal returns documented in prior research is mitigated by managerial ability. Specifically, more able managers appear to utilize equity issuance proceeds more effectively, illustrating that our more precise measure of managerial ability will allow researchers to pursue studies that were previously difficult to conduct.

Key words: managerial ability; managerial talent; managerial efficiency
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1. Introduction

Quantifying managerial ability, or talent, is central to many important research questions, such as those examining managerial contributions to firm performance and investment decisions, executive compensation, corporate governance, economic effects of corporate ownership, and cross-country productivity differences. Prior research indicates that manager-specific features (ability, talent, reputation, or style) affect economic outcomes and are therefore important to economics, finance, accounting, and management research as well as to practice.[1] To infer managerial ability, researchers generally rely on proxies such as firm size, past abnormal performance, compensation, tenure, media mentions, education, or manager fixed effects. Researchers have also inferred the ability of managers using data envelopment analysis (DEA) within specific industries (e.g., Leverty and Grace 2012). Most of these measures, however, also reflect significant aspects of the firm that are outside of management's control. For example, media mentions are more prevalent for large firms, and abnormal stock returns are affected by many factors other than managerial ability. Similarly, although manager fixed effects are more directly attributable to management, they can be applied only to a relatively small sample of firms and do not offer a stand-alone measure of ability.

We introduce a new measure of managerial ability based on managers' efficiency, relative to their industry peers, in transforming corporate resources to revenues. We consider a multitude of revenue-generating resources: cost of inventory, general and administrative expenses, fixed assets, operating leases, past research and development (R&D) expenditures, and intangible assets. We expect more able managers to better understand technology and industry trends, reliably predict product demand, invest in higher value projects, and manage their employees more efficiently than less able managers. In short, we expect more able managers to generate higher revenue for a given level of resources or, conversely, to minimize the resources used for a given level of revenue (i.e., to maximize the efficiency of the resources used). Assessing managers based on the efficiency

[1] For example, Bertrand and Schoar (2003) document that managers exhibit styles that are reflected in the underlying decisions of the company (e.g., aggressive R&D investment or merger and acquisition activity); see §2 for additional studies.

with which they generate revenues, rather than by their pay or media mentions, is intuitively appealing as it is more in line with the overarching goal of profit-maximizing firms.

We use DEA to create an initial measure of the relative efficiency of the firm within its industry.[2] We form an efficient frontier by measuring the amount and mix of resources used to generate revenue by the firms within each industry. Firms operating on the frontier are assigned a score of one; the lower the firm's score, the further it is from the frontier.

This firm efficiency measure, however, is affected by both firm-specific factors and management characteristics, a limitation that also applies to other managerial ability proxies frequently used in the literature, such as past stock returns, as well as to conventional efficiency measures, such as return on assets (ROA). For example, a mediocre manager of a large company will be able to negotiate better terms with suppliers than an outstanding manager of a small company. We therefore modify the DEA-generated firm efficiency measure by purging it of key firm-specific characteristics that we expect to aid or hinder management's efforts. We do this by removing from the total firm efficiency measure the effects of firm size, market share, positive free cash flow, and firm age (all aiding management), as well as complex multi-segment and international operations (challenges to management). We also remove the effects of industry and time in the estimation. After controlling for the above, we attribute the unexplained portion of firm efficiency to management. This unexplained portion may still contain other unidentified drivers of firm efficiency, and we conduct a number of validity tests to assess whether the measure reflects managerial ability.[3]

Although our measure of managerial ability is positively correlated with a number of alternative measures of ability (historical industry-adjusted stock returns, historical industry-adjusted return on assets, chief executive officer (CEO) pay, and CEO tenure), we show that it dominates these alternative measures in a number of ways. First, for a subset of 78 CEOs who switch firms within our sample, we examine the explanatory power of manager fixed effects in explaining managerial ability. We find that 60.5% of these manager fixed effects are statistically significant in explaining managerial ability after controlling for firm fixed effects, and that this is 31.4 percentage points higher than the statistical significance of firm fixed effects (where only 29.1% are statistically significant). These results indicate that our proposed ability measure reflects, to a large extent, individual managers, although firm fixed effects continue to have explanatory power, albeit weaker. Moreover, manager fixed effects are notably higher than firm fixed effects only for our ability score. For the alternative measures, the range varies from 7.5% (historical returns) to −3.6% (historical ROA). Second, for a sample of 2,229 firms experiencing a CEO turnover during our sample period, we correlate managerial ability and announcement returns to CEO departures. We find that the turnover announcements of outgoing CEOs with low (high) ability are associated with positive (negative) stock price reactions. We do not find a similar association for any of the alternative measures of ability. Third, for CEOs switching firms within our sample, we examine performance changes at the CEO's new firm. Specifically, we document that when a firm hires a more able CEO (relative to the outgoing CEO), firm performance improves over the next three years (measured using changes in both industry-adjusted stock returns and industry-adjusted return on assets). Our measure again outperforms the alternative measures in this setting. Thus, although our proposed measure encompasses some aspects that are not directly attributable to managerial ability, the partitioning is more precise than that of existing measures, and it appears to capture an economically significant manager-specific component of ability.

We conclude our study by demonstrating that our more precise measure of managerial ability can help resolve extant research puzzles. We examine whether managerial ability plays a role in the new issue puzzle documented by Loughran and Ritter (1995). Specifically, seasoned equity offerings are associated with future negative abnormal returns, and Loughran and Ritter (1997) suggest that this is, in part, a result of overly optimistic managers investing the proceeds in negative net present value projects. We hypothesize and find evidence suggesting that more able managers utilize the proceeds from equity financing more effectively, thereby largely mitigating the previously documented negative future abnormal returns.

In sum, we propose a measure of managerial ability that is based on easily obtainable financial data and

[2] DEA is an optimization procedure used to evaluate the relative efficiency of decision-making units. In §3 we provide additional detail on DEA and discuss the merits of DEA over conventional ratios (i.e., return on assets) and a regression analysis of the same variables.

[3] We attribute our managerial ability measure to the management team, though in tests examining a specific manager, we focus on the CEO, who is the most powerful manager and thus, on average, the most likely to affect outcomes (Fee and Hadlock 2003). Although a number of papers have used DEA to measure firm efficiency (e.g., Thore et al. 1994; Murthi et al. 1996, 1997; Barr and Siems 1997; Berk and Green 2004; Berk and Stanton 2007; Leverty and Grace 2012), we are the first to measure efficiency for a large cross section of firms, spanning most industries, and parse out key firm-specific drivers of efficiency to focus on managerial ability.

available for a broad cross section of firms. Our managerial ability score exhibits an economically significant manager-specific component and contains less noise than existing proxies of managerial ability. This more precise measure of ability opens the door to a wide array of studies that previously were difficult to conduct.

2. Hypothesis Development

The impact of management on firm performance is an important research question considered in the economics, finance, accounting, and management literatures (see Harris and Holmstrom 1982, Rose and Shepard 1997, Hermalin and Weisbach 1998, Bertrand and Mullainathan 2003, Bertrand and Schoar 2003, Malmendier and Tate 2005, Perez-Gonzalez 2006, Silva 2010). Several studies use DEA to measure managerial skills or talent for firms within a single industry. Murthi et al. (1996) examine consumer goods in the mature stage of the product life cycle and use DEA to form their estimate of management skills, whereas in the banking and insurance industries, Barr and Siems (1997) and Leverty and Grace (2012) use DEA to measure managerial ability and find that more able managers are associated with lower likelihoods of bankruptcy. Finally, Murthi et al. (2007) attribute the relative efficiency scores generated across mutual funds to the mutual fund managers. In each of these studies, the inputs and outputs to the DEA vectors are industry specific. For example, in Murthi et al. (1996) the inputs include product quality and product price, and the outputs include market share. In the Leverty and Grace (2012) insurance study, the inputs include administrative and agent labor, and the outputs include the present value of real losses incurred for personal and commercial short-tail lines. In contrast, our managerial ability measure extends across industries and does not require hand-collected or proprietary data.

A number of studies focus on broader, but potentially less precise, measures of ability. For example, Fee and Hadlock (2003) use prior industry-adjusted stock returns as a proxy for managerial ability and report that top executives in firms with high returns are more likely to be hired away by other firms and receive higher wages at their new firm. Similarly, Rajgopal et al. (2006) measure talent by the CEO's financial press visibility (using prior media mentions) and the firm's prior industry-adjusted return on assets and show that outside employment opportunities increase with managerial talent. Milbourn (2003) documents that more able managers have higher pay-for-performance sensitivities, using CEO tenure, prior media mentions, appointment from outside of the firm, and prior industry-adjusted stock returns as a proxy for managerial ability. Finally, several studies have used executive pay to infer managerial ability, either directly (e.g., Tervio 2008, Carter et al. 2010) or to corroborate their measures of ability (e.g., Fee and Hadlock 2003). Prior research has acknowledged that existing ability measures contain noise and are difficult to attribute solely to the manager. For example, large firms tend to have more media mentions and higher compensation, all else equal, whereas prior abnormal stock returns encompass information above and beyond management's control.

Other studies examine shocks to the firm to assess the impact of management. For example, Hayes and Schaefer (1999) identify able managers as those who were hired away by another firm, and they document an average negative stock price reaction of −1.51% for these 129 departures. The authors estimate that the market value of differences in managerial ability ranges from \$12.6 to \$53.3 million and conclude that managerial ability effects on shareholder wealth are substantial. Bennedsen et al. (2010) examine subsequent performance, rather than price reactions to turnovers. The authors examine firm profitability following deaths affecting the CEO (i.e., CEO deaths as well as those of family members) and report that firm profitability declines, on average, following the deaths, also supporting the notion that managers have an economically significant effect on the firm. Both studies, however, rely on infrequent events.

Arguably, the strongest evidence supporting the claim that individual managers have a measurable impact on their firms comes from studies examining manager fixed effects (e.g., Bamber et al. 2010, Ge et al. 2011). For example, Bertrand and Schoar (2003) document that managers' styles affect the choices made by their firms (e.g., R&D and merger and aquisition activity), and that manager fixed effects are correlated with the performance of the firm. Though useful in documenting that individual managers are associated with firm outcomes, fixed effects are difficult to implement as a measure of managerial ability for several reasons. First, the firm must experience at least one manager turnover during the sample period examined to differentiate manager fixed effects from firm fixed effects. Second, fixed effects do not immediately offer a generalizable ordinal ranking of quality, though one can use the coefficient on the fixed effect to infer quality over a particular dimension. For example, Bertrand and Schoar (2003) find that, after sorting managers based on the magnitude of their fixed effects on return on assets, a manager in the top (bottom) quartile of the distribution increases (decreases) the rate of return on assets by about 3%.

Regardless, it is clear from these studies that managers affect the firm.[4]

The contribution of this study is to advance a more precise measure of managerial ability; thus, we hypothesize that our proposed measure reflects managerial ability and outperforms existing ability measures. We test this hypothesis three ways. First, following Bertrand and Schoar (2003), we expect that the proposed measure will be economically and significantly associated with manager fixed effects. Second, in the vein of Hayes and Schaefer (1999), we expect that the proposed measure will be negatively associated with the announcement returns to CEO turnovers. Specifically, we expect that the turnover announcement of low-ability (high-ability) managers will lead to a positive (negative) price reaction. Third, along the lines of Bennedsen et al. (2010), we expect that relative changes in ability will be associated with changes in subsequent performance (e.g., Carter et al. 2010, Cazier and McInnis 2010). Moreover, we expect our managerial ability measure to outperform the alternative ability measures in each of these respects.

3. Generation of Firm Efficiency Measure Using Data Envelopment Analysis

3.1. Overview

In this section we briefly describe the DEA methodology (Charnes et al. 1978, Banker et al. 1984) and compare it to more conventional efficiency measures. We use DEA to generate a measure of firm efficiency; this is the first step in generating our managerial ability measure, which is the residual of total firm efficiency after removing a number of firm-specific characteristics. DEA has been used to measure efficiency across multiple disciplines. For example, Murthi et al. (1996) use DEA analysis to assess marketing efficiency, and Leverty and Grace (2012) use DEA to examine the relative efficiency of insurance companies; both of these studies attribute the resulting efficiency score (total firm efficiency herein) to management quality.

[4] Whereas Bertrand and Schoar (2003) examine the styles of the executives, other studies examine specific managerial traits. For example, Billet and Qian (2008) conclude that self-attribution bias leads to CEO overconfidence, and Malmendier and Tate (2005) find that overconfident CEOs (i.e., those who repeatedly fail to exercise in-the-money options or habitually acquire their company's stock) cause distortions in corporate investment policies. Chatterjee and Hambrick (2007) examine the effects of narcissistic CEOs using six measures of narcissism, including the prominence of the CEO's photo in the annual report and the length of the CEO's Who's Who entry; they report that CEO narcissism is associated with organizational strategy changes, a greater number and size of acquisitions, and extreme performance.

3.2. DEA Fundamentals

3.2.1. Framework. DEA is a statistical procedure used to evaluate the relative efficiency of separable entities, termed "decision-making units" (DMUs), where each DMU converts certain inputs (labor, capital, etc.) into outputs (revenue, income, etc.). As with the more widely used efficiency measures, such as the return on assets and other profitability ratios, DEA efficiency is defined as the ratio of outputs over inputs:

$$\frac{\sum_{i=1}^{s} u_i y_{ik}}{\sum_{j=1}^{m} v_j x_{jk}} \quad k = 1, \ldots, n. \tag{1}$$

In Equation (1), there are s outputs, m inputs, and n DMUs. In our study, we use firms as the DMUs and consider one output and seven inputs, all derived from firms' publicly available financial reports. Revenue is the sole output measure; we characterize an able management team as one that generates the highest level of revenue from a given set of inputs.[5] We consider the following inputs into the revenue production process: *Net Property, Plant, and Equipment* (*PP&E*); *Net Operating Leases*; *Net R&D*; *Purchased Goodwill*; *Other Intangible Assets*; *Cost of Inventory*; and *Selling, General, and Administrative Expenses* (*SG&A*). All these inputs contribute to the generation of revenue and are affected by managerial ability, as each of the inputs is subject to managerial discretion. We motivate and describe each of these variables in §4.

Each output and each input are assigned a weight in calculating the efficiency score, where the weights are denoted by u and v for the outputs and inputs, respectively. The quantities of outputs and inputs are denoted by y and x. The DEA optimization procedure involves the following steps:

1. We sort DMUs into groups (e.g., industries) within which the relative efficiency program is estimated. The groups are determined based on similarities in the underlying relations between input

[5] Possible alternative (or additional) outputs are net income and the market value of equity. Because we consider expenses as inputs, net income is effectively an aggregation of our output and inputs (revenue less expenses), and thus we opt to use individual expenses as inputs rather than aggregating expenses and revenues and using net income as our output. Market value of equity is a noisy output because it is affected by many factors beyond management's control. Clearly not all researchers would wish their "output" to be revenues. The model in this paper can be used as a basic framework and can be adapted to consider additional or different inputs or outputs. For example, a researcher wishing to examine managerial ability and R&D would clearly want to exclude R&D from the input set, and a researcher wishing to consider nonfinancial performance metrics could include measures of customer satisfaction, or other metrics, in the output set. Researchers wishing to look at one-year changes following turnovers could also adapt the model to consider only short-term investments, and instead control for previous investments in Equation (3).

and outputs so that DMUs within each group are comparable.

2. Next, we maximize Equation (1) for each DMU by varying the weights u and v. This maximization uses all DMUs in the group and determines the weights that maximize Equation (1) for each DMU relative to other DMUs in the group. The resulting weights are DMU specific.

3. The derived optimal weights are then multiplied by the corresponding output and input quantities and summed across all outputs (in the numerator) and inputs (in the denominator). This yields a ratio-based efficiency score for each DMU.

4. All efficiency scores are then scaled by the highest efficiency score within the group, resulting in an ordinal sorting of DMUs on relative efficiency where the most efficient DMUs have a value of one, indicating optimal efficiency. For example, if the highest unscaled efficiency score is 3.2, then that DMU would have a score of one (3.2/3.2), whereas a firm with an unscaled efficiency of 2.2 would have a score of 0.6875 (2.2/3.2).

5. The weights, u and v, are constrained to be nonnegative. This presumes that each input and output is valuable. Because the quantity of each input and output is also nonnegative, the lower bound on the DEA efficiency score is zero.

3.2.2. Advantages of DEA. The DEA efficiency methodology has two key advantages over conventional measures of efficiency. First, DEA provides an ordinal ranking of relative efficiency compared to the Pareto-efficient frontier—the best performance that can be practically achieved. Parametric methods, such as regression analysis and basic ratio comparisons, estimate efficiency relative to *average* performance, which is lowered disproportionately by inefficient industry peers. To illustrate that this difference is economically important, we reestimate our efficiency measure using ordinary least squares (OLS) regression, with revenue as the dependent variable and the inputs (resources), scaled by beginning of period total assets to adjust for size effects, as the independent variables. We estimate the regression by industry and interpret the residual as the over- or underperformance of a specific firm relative to its industry peer group. Firms with positive residuals are more efficient, and those with negative residuals are less efficient, than other firms in the industry. We find that the regression residuals and the DEA firm efficiency measure have a relatively low correlation of 0.079, which increases to only 0.109 for the rank (Spearman) correlation, suggesting that the low correlation is not a scale effect. Rather, the difference in efficiency measures illustrates the multidimensional nature of DEA relative to OLS regression. DEA allows different firms to optimize across different outputs and inputs, and it compares each firm to the most efficient outcome, whereas the regression analysis benchmarks each firm against the average firm, resulting in a fundamentally different efficiency ranking.[6]

The second key advantage of DEA is that widely used efficiency measures, such as return on assets, require that weights be explicitly set, often assuming that all inputs and outputs are equally valuable across DMUs. The DEA procedure calculates efficiency without imposing an explicit, ad hoc weighting structure. If two firms produce the same output, but do so with different mixes of inputs (even if the dollar value of the inputs differs), both are considered efficient. With a sufficient number of observations, the frontier is formed using all possible combinations of inputs. Those DMUs using a less than optimal mix to reach the same level of outputs receive efficiency scores of less than one.

4. Data, Variable Definitions, and Descriptive Statistics

4.1. Data

For the empirical analysis, we obtain data from the following sources: the 2009 annual Compustat file (for financial statement data), the Center for Research in Security Prices (CRSP) file (for returns data), the Execucomp database (for executive compensation and tenure, and to track managers across firms, with coverage from 1992 to 2009), the Morningstar database (to track additional managers across firms, with coverage from 1999 to 2009), and Audit Analytics (to obtain the 8-K filing dates of CEO turnover announcements, with coverage from 2000 to 2009). The sample includes all firm-year observations from 1980 to 2009 with the required data to calculate the firm efficiency measure, yielding 177,512 firm-year observations. Our managerial ability measure (a residual from the firm efficiency measure, described in detail below) requires additional data, yielding a final sample of 177,134 firm-year observations. The sample period begins with 1980 because many of the variables were missing in Compustat before 1980.

[6] We empirically assess whether the multidimensionality of the DEA measure of managerial ability is more highly correlated with prior proxies of ability than the two-dimensional regression approach. We find the DEA measure is more highly correlated with each of the alternative proxies. Specifically, the correlations between the DEA-based measure of managerial ability and the five alternative measures are 0.169, 0.065, 0.042, 0.060, and −0.100, for historical return, historical return on assets, compensation, tenure, and media citations, respectively (see Table 4), whereas the correlations between the two-dimensional regression approach and these five alternative measures are 0.039, 0.032, −0.017, 0.020, and −0.048 (not tabulated).

4.2. Measurement and Summary Statistics of the Firm Efficiency Measure

4.2.1. Inputs and Output of the Firm Efficiency Measure. We introduce the inputs and output of the efficiency measure here. All data were obtained from Compustat, and the Xpressfeed data names are provided in quotations. To form the portfolio of inputs, we first consider acquired assets, both tangible and intangible, because the management team has a great deal of latitude in asset purchase and retirement decisions, and a more capable management team is expected to make more efficient purchasing decisions.

The first acquired asset, *Net PP&E* ("PPENT"), is reported on the balance sheet and reflects the undepreciated portion of purchased fixed assets. An alternative way to gain access to similar fixed assets is through the use of operating leases, used across many sectors (airlines, retailers, hotels). The structure of operating leases allows firms to exclude the asset (and related debt) from their balance sheet, although these assets will generate revenues; thus, we estimate their capitalized value. We calculate *Net Operating Leases* as the discounted present value of the next five years of required operating lease payments (available in the firm's footnotes to the financial statements and on Compustat).[7] The inclusion of *Net Operating Leases* as an input increases the input comparability among firms that effectively have the same operations but either lease or buy their revenue-generating equipment.

We include *Net R&D* as an input, expecting that more capable managers will be better able to determine which R&D projects to pursue. To calculate *Net R&D*, which is not reported as an asset on the balance sheet, we follow Lev and Sougiannis (1996), who use a five-year capitalization period of R&D expense ("XRD"), where the net value (net of amortization) is $RD_{cap} = \sum_{t=-4}^{0}(1 + 0.2t) \times RD_{exp}$. Thus, for example, R&D expenditures from five years back receive a weight of 0.2 (they were already amortized 80%), those from four years back receive a weight of 0.4 (amortized 60%), etc., with the prior year's R&D ($t = -1$) receiving full weight. We next include *Purchased Goodwill*, reported on the balance sheet, which is the excess of the purchase price for a business acquisition over the amounts allocated to other separately identifiable assets and liabilities ("GDWL"). Goodwill generally reflects the value of the acquired intangible assets. We add to it "other acquired and capitalized intangibles" ("INTAN" less "GDWL"), also reported on the balance sheet, which includes items such as client lists, patent costs, and copyrights. We consider the beginning of period balance for each of the five assets, because managers' past decisions regarding these assets are expected to affect current period revenues.[8]

Inventory and advertising expenditures also contribute to the generation of revenues. For inventory, we consider the total amount of inventory sold during the period—the cost of inventory, or cost of goods sold—to appropriately match the input to the revenues generated.[9] Finally, advertising expenditures are often missing in Compustat, introducing a prohibitive data restriction. Instead, we include the current period value of *SG&A* ("XSGA"), which includes advertising expenditures.[10] This variable also captures other assets that are not explicitly recognizable as accounting assets, such as the quality of the sales force (training costs and information technology services are included in SG&A).

Specifically, we solve the following optimization problem:

$$\max_{\mathbf{v}} \theta = (Sales) \cdot \big(v_1 CoGS + v_2 SG\&A + v_3 PPE + v_4 OpsLease + v_5 R\&D + v_6 Goodwill + v_7 OtherIntan\big)^{-1}. \quad (2)$$

The five stock variables (*Net PP&E*, *Net Operating Leases*, *Net Research and Development*, *Purchased Goodwill*, and *Other Intangible Assets*) are measured at the beginning of year t, and the two flow variables (*Cost of Inventory* and *SG&A*) are measured over year t. These seven inputs capture, to a large degree, the choices managers make in generating revenue. We estimate DEA efficiency by industry (based on Fama and French 1997) to increase the likelihood that the

[7] Note that capital leases are included in *Net PP&E*. The data items for the five lease obligations are "MRC1–MRC5." We would also like to discount the "thereafter" payments; however, this line item was not collected by Compustat for the bulk of the sample period. We use a discount rate of 10% per year to calculate the present value of the required operating lease payments following Ge (2006), who finds that results are substantively unchanged using alternative discount rates of 8%, 12%, or the short-term average borrowing rate. Our empirical results are qualitatively and quantitatively similar if we exclude operating leases from the DEA estimation (not tabulated).

[8] For example, Sunder (1980) finds that purchases of PP&E take an average of two years to generate positive earnings.

[9] It is likely that more efficient managers might require less buffer stock or be more likely to use just-in-time inventory processes (Callen et al. 2005), which would also lower average inventory balances, providing some support for considering the beginning balance of inventory instead of total cost of inventory sold during the period. However, the beginning balance could be low for other reasons, such as a cash shortage.

[10] Operating lease expense and research and development expense are both components of SG&A expense; to avoid counting these items twice in the input vector, we subtract the current year operating lease expense and research and development expense from SG&A expense.

peer firms have similar business models and cost structures within the estimations.

Measurement Error in Accounting Variables. We use accounting values to construct firm efficiency and hold the quality of financial reporting quality constant, which introduces several limitations to this paper. First, there is known variation in financial reporting quality because of intentional manipulations—especially to revenues (e.g., Dechow et al. 1996). Although it is possible that earnings management inflates the perceived efficiency of a firm, Demerjian et al. (2011) find that more able managers are associated with *fewer* subsequent earnings restatements, indicating that earnings management is not the primary driver of perceived efficiency. It remains, however, that earnings management will inflate perceived efficiency. Second, measurement error also stems from our reliance on accounting numbers formed using recognition and measurement rules under U.S. GAAP (generally accepted accounting principles). For example, historical cost measurement is not comparable across firms (Curtis and Lewis 2010); we must rely on researcher assumptions to measure capitalized R&D and capitalized operating leases, and we must omit other important intangibles such as purchased R&D because of data constraints. Finally, we rely on imperfect industry groupings. We estimate Equation (1) by industry according to Fama and French (1997), but most firms operate in several industries, and even within industries the relation between the accounting inputs and outputs can vary substantially depending on firms' asset and operations mix. Although we do not expect these measurement errors to systematically affect our managerial ability score, they do introduce the potential for confounding effects on the efficiency score and, thus, the inferences of the study.

4.2.2. Summary Statistics of Firm Efficiency. Panel A of Table 1 provides summary statistics of the firm efficiency measure—the starting point for the development of our managerial ability measure—for the full sample. Recall that DEA constrains the firm efficiency measure to be between zero and one. The mean value reported in Table 1 is 0.569, with a median value of 0.588. A total of 4.5% of observations are on the frontier (not tabulated).

We estimate firm efficiency by industry group, because we expect firms in the same industry to have similar technologies and business structures for converting inputs into outputs. Because DEA requires a sufficiently large number of observations to provide a valid estimation, we partition the sample by industry and not by time; it is likely that an industry's business model will remain stable over time.[11] We exclude from the sample financial services firms (banks, insurance, real estate, and finance companies) because of the uniqueness of their asset structure and earnings generating processes; we also exclude utilities because of regulation of the output price.

Panel B of Table 1 presents summary statistics of firm efficiency by industry groups (based on Fama and French 1997). There is considerable firm efficiency variation across industries. The mean and median industry values are 0.672 and 0.674, respectively, whereas the range of scores is large, with a low mean score of 0.271 (drugs) to a high of 0.942 (ships).[12]

Finally, because we estimate firm efficiency by industry but not by year, we examine summary statistics by year (not tabulated); the largest average value is 0.623 (1980), and the smallest is 0.537 (2001). Although there is not a lot of year-to-year variation, we include year fixed effects in each of our regressions.

4.3. Estimation of Managerial Ability

Firm efficiency could be used to assess managerial ability; however, this measure captures both firm-specific and manager-specific efficiency drivers, and thus it likely overstates or understates managerial ability, depending on the firm-specific efficiency drivers. We parse out total firm efficiency into firm efficiency and managerial ability by regressing total firm efficiency on six firm characteristics that affect firm efficiency: firm size, firm market share, cash availability, life cycle, operational complexity, and foreign operations.

First, we expect that managers of larger firms with more market share will be more effective than others in negotiating terms with suppliers and customers, holding their ability constant. Second, we expect managers in firms with available cash (measured with an indicator variable indicating positive free cash flows) to be able to pursue positive net present value projects more effectively, again holding ability constant. Third, we expect the life cycle of the firm to affect management's opportunity set of possible projects as well

[11] When there are too few firms, a large percentage of these firms will be on the frontier, especially when there are multiple inputs. The efficient frontier consists of, at a minimum, the sum of the number of inputs and outputs, and because we use the variable returns-to-scale model in calculating DEA, there are additional points on the frontier to accommodate different firm sizes. Therefore, we require at least 100 observations to estimate DEA. Alternatively, Leverty and Qian (2011) estimate a very similar estimation by industry and year, resulting in a higher average firm efficiency score (0.745 for the full sample; see their Table 1).

[12] The percentage of observations making up the efficient frontier also varies across industries, ranging from 1.6% (business services) to 28.5% (guns) (not tabulated). This effect is likely driven in part by the competitiveness of different industries, but is also a function of the number of observations available to estimate the frontier (see also Footnote 11). This is a potential concern for users of DEA; however, we estimate the second-stage regression by industry, removing systematic differences in efficiency across industries.

Table 1 Sample Statistics on Firm Efficiency

	Obs.	Mean	Std. dev.	25%	Median	75%
Panel A: Firm efficiency measure						
Variable						
Firm Efficiency	177,512	0.569	0.273	0.347	0.588	0.802
Panel B: Firm efficiency measure by industry						
Industry						
Agriculture	780	0.778	0.220	0.617	0.844	0.984
Food	3,672	0.773	0.156	0.652	0.800	0.897
Soda	460	0.896	0.138	0.848	0.954	1.000
Beer and liquor	733	0.826	0.143	0.764	0.853	0.928
Smoking	268	0.854	0.158	0.753	0.905	1.000
Toys	1,868	0.702	0.194	0.590	0.700	0.829
Fun	4,038	0.430	0.251	0.234	0.381	0.577
Books	2,027	0.796	0.154	0.697	0.818	0.913
Household products	4,065	0.680	0.196	0.513	0.680	0.846
Clothing	2,803	0.732	0.145	0.636	0.719	0.828
Health	3,528	0.737	0.178	0.627	0.756	0.866
Medical equipment	6,274	0.456	0.231	0.294	0.417	0.578
Drugs	8,447	0.271	0.253	0.088	0.200	0.345
Chemicals	3,723	0.717	0.187	0.609	0.732	0.845
Rubber	2,308	0.834	0.141	0.780	0.857	0.926
Textiles	1,422	0.834	0.108	0.782	0.842	0.906
Building materials	4,720	0.608	0.231	0.458	0.613	0.785
Construction	2,673	0.669	0.186	0.578	0.675	0.784
Steel	3,258	0.700	0.136	0.610	0.690	0.785
Fabricated products	994	0.874	0.095	0.815	0.877	0.954
Machinery	7,085	0.637	0.234	0.450	0.676	0.823
Electrical equipment	2,129	0.728	0.186	0.614	0.735	0.863
Utilities	1,309	0.616	0.301	0.375	0.647	0.897
Automobiles	3,039	0.783	0.194	0.736	0.832	0.911
Aerospace	1,009	0.860	0.123	0.773	0.876	0.973
Ships	433	0.942	0.075	0.911	0.969	1.000
Guns	323	0.878	0.174	0.810	0.949	1.000
Gold	1,684	0.342	0.277	0.121	0.255	0.518
Mining	1,162	0.281	0.254	0.116	0.203	0.349
Coal	328	0.802	0.187	0.722	0.835	0.962
Energy	10,995	0.328	0.269	0.128	0.219	0.485
Telecom	7,799	0.591	0.229	0.448	0.603	0.754
Personal services	1,996	0.685	0.195	0.574	0.691	0.820
Business services	21,884	0.381	0.227	0.226	0.333	0.500
Computers	9,055	0.459	0.215	0.314	0.431	0.571
Chips	11,516	0.472	0.190	0.360	0.446	0.553
Laboratory equipment	4,481	0.577	0.202	0.447	0.560	0.697
Paper	3,012	0.807	0.119	0.746	0.802	0.875
Boxes	705	0.933	0.070	0.898	0.950	0.991
Transportation	5,752	0.650	0.225	0.447	0.691	0.839
Wholesale	8,919	0.647	0.203	0.528	0.676	0.792
Retail	10,453	0.826	0.119	0.775	0.842	0.903
Restaurants	4,383	0.517	0.246	0.324	0.464	0.710
Average (43 industries)	4,128	0.672	0.186	0.553	0.674	0.799

Notes. The sample consists of 177,512 firm-year observations from 1980 to 2009. *Firm Efficiency* is measured using DEA based on the vectors described in §4.2. Panel A presents statistics for the full sample. Panel B is sorted by industry, based on Fama and French (1997).

as the required start-up costs of investments. We use the number of years the firm has been listed as a proxy for a firm's life-cycle stage (DeAngelo et al. 2010). Finally, we consider the diversification of a firm's operations, both operationally and geographically. We expect that the greater the diversification, the more challenging it is for the management team to efficiently allocate capital, because operating in multiple industries requires a broader knowledge set and reduces the amount of attention management pays to any single industry (e.g., Stein 1997). We measure operational complexity using the within-firm industry

concentration (e.g., Bushman et al. 2004) as well as an indicator variable signifying foreign operations. Thus, to form our estimate of managerial ability, we estimate the following Tobit regression by industry and include year fixed effects; we cluster standard errors by firm and year to control for cross-sectional and intertemporal correlation:

$$\begin{aligned} &\textit{Firm Efficiency}_i \\ &\quad = \alpha + \beta_1 \ln(\textit{Total Assets})_i + \beta_2 \textit{Market Share}_i \\ &\qquad + \beta_3 \textit{Free Cash Flow Indicator}_i + \beta_4 \ln(\textit{Age})_i \\ &\qquad + \beta_5 \textit{Business Segment Concentration}_i \\ &\qquad + \beta_6 \textit{Foreign Currency Indicator}_i + \textit{Year}_i + \epsilon_i. \end{aligned} \quad (3)$$

Because we estimate Equation (3) by industry, we do not include industry-level drivers of efficiency such as competition. This estimation dampens variation in ability, for example, by controlling for firm size, because better managers are more likely to be hired by larger firms (Rosen 1982).[13] Managerial ability could also affect the variables we attribute to the firm, such as market share (e.g., Vanhonacker and Day 1987). We opt to err on the side of attributing manager characteristics to the firm, to maximize the likelihood that the residual is largely attributable to the manager.

We summarize the results from this estimation, as well as the definitions of the variables, in Table 2. We present the average coefficient across the 43 industry estimations and note the significant percentage and the percentage with the predicted sign. For example, the coefficient on firm size (the natural log of total assets) has a one-tailed p-value of less than 0.05 in 90.7% of the industry estimations, and all 43 coefficients are positive as expected. The average coefficients on each of the independent variables are significant in the predicted direction (using the standard error of industry-level coefficients to test significance along the lines of Fama and MacBeth 1973), supporting our decision to remove these firm effects from the firm efficiency measure to create our managerial ability measure. The importance of some of the variables varies by industry; for example, while the free cash flow indicator is statistically significant in the predicted direction in 40 of the 43 industries, business concentration is significant in less than half of the industries.[14]

Table 2 Managerial Ability

Dependent variable = *Firm Efficiency*				
	Predicted sign	Average coefficient (Fama–MacBeth t-statistic)	Proportion significant (%)	Proportion with predicted sign (%)
Ln(*Total Assets*)	+	0.037*** (11.51)	90.7	100.0
Market Share	+	1.599*** (5.61)	65.1	76.7
Free Cash Flow Indicator	+	0.075*** (11.12)	93.0	100.0
Ln(*Firm Age*)	+	0.021*** (6.52)	67.4	86.1
Business Segment Concentration	−	0.029*** (3.12)	41.9	67.4
Foreign Currency Indicator	−	−0.014** (−2.46)	67.4	72.1
Intercept		0.567*** (16.71)		
Year fixed effects		Included		
Industry estimations		43		

Notes. This table presents the averages from the Tobit estimation of Equation (3) by industry; the residual from the estimation is *Managerial Ability*, described in §4.3. For illustrative purposes, we present the average of the industry coefficients and calculate the Fama and MacBeth (1973) t-statistic based on the standard error of these coefficients (in parentheses). The significant percentage is the number of coefficients that are statistically significant at the 5% level (one-tailed) across the 43 industry regressions using standard errors clustered by firm and year. The Percentage with predicted sign is the proportion of the 43 industry coefficients with the predicted sign. Variables are defined as follows (with Compustat identifiers in parentheses): *Firm Efficiency* is measured using DEA based on the vectors described in §3.2. *Total Assets* is Compustat (AT) at the end of year t. *Market Share* is the percentage of revenues (SALE) earned by the firm within its Fama and French (1997) industry in year t. *Free Cash Flow Indicator* is coded to one when a firm has nonnegative free cash flow (defined as earnings before depreciation and amortization (OIBDP) less the change in working capital (RECT + INVT + ACO − LCO − AP) less capital expenditures (CAPX)) in year t. *Firm Age* is the number of years the firm has been listed on Compustat at the end of year t. *Business Segment Concentration* is the ratio of individual business segment sales to total sales, summed across all business segments for year t. If the firm is not in the segment file, it is assigned a concentration of one. *Foreign Currency Indicator* is coded to one when a firm reports a nonzero value for foreign currency adjustment (FCA) in year t. Variables are winsorized at the extreme 1%.

**5% and ***1% statistical significance (two-tailed tests).

The residual from this estimation is our measure of managerial ability.[15] Table 3 presents summary statistics. The mean value of our managerial ability

[13] As an illustration of this limitation, Jack Welch is assigned a low ability score using this estimation because GE's size, market share, and age (each of which are in the highest percentile) predict a total efficiency score of one for GE. If we exclude these variables from Equation (3), Welch's ability score is high, as expected.

[14] To assess the economic significance of the firm-specific portion of total efficiency, we estimate Equation (3) by industry using OLS regressions (Tobit regressions do not have a goodness-of-fit measure analogous to adjusted R^2). We find the average adjusted R^2 is 37.4%, suggesting that, on average, over one-third of total firm efficiency is attributable to the firm features we have identified in Equation (3).

[15] The estimation of Equation (3) may not fully ameliorate the impact of unidentified features, such as unions or investor base, that affect managers' ability to utilize firm resources. One alternative to better capture these unidentified drivers of efficiency would be to include firm fixed effects. We opt to present the residual

Table 3 Descriptive Statistics

Variable	Observations	Mean	Standard deviation	Min	1%	25%	Median	75th	99%	Max
Firm Efficiency	177,512	0.569	0.273	0.000	0.024	0.347	0.588	0.802	1.000	1.000
Managerial Ability	177,134	−0.004	0.149	−0.415	−0.349	−0.094	−0.013	0.075	0.451	0.557
Fitted Value of Ability	22,982	0.000	0.111	−0.374	−0.194	−0.074	−0.013	0.065	0.462	0.936
Alternative measures of ability										
Historical Return	83,652	0.224	2.345	−6.274	−3.371	−0.954	−0.257[a]	0.688	10.281	22.455
Historical ROA	125,487	−0.346	1.783	−26.847	−7.730	−0.286	0.000	0.204	0.953	1.243
CEO Cash Compensation	22,982	1,183.610	1,572.510	0.000	50.000	535.000	849.277	1,357.200	5,928.740	77,926.000
CEO Tenure	22,113	7.465	7.539	0.000	0.000	2.167	5.003	10.005	35.855	58.786
Media Mentions	14,943	213.473	706.688	0.000	2.000	46.000	93.000	182.000	2,016.000	43,152.000

Notes. Firm Efficiency is measured using DEA based on the vectors described in §3.2. *Managerial Ability* is the residual-based measure described in §4.3. *Fitted Value of Ability* is the fitted value of available manager fixed effects on firm efficiency described in §4.3. *Historical Return* is the five-year historical value-weighted industry-adjusted return (from year $t-5$ to year $t-1$). *Historical ROA* is the five-year industry-adjusted return on assets (cumulative income before extraordinary items (IBC) scaled by average total assets (AT) from year $t-5$ to year $t-1$). *CEO Cash Compensation* is the salary and bonus of the firm CEO (TOT_CURR from Execucomp; in thousands) for year t. *CEO Tenure* is the number of years an executive has been listed as CEO by Execucomp at the end of year t. *Media Mentions* is the number of articles mentioning the CEO over the preceding five-year period. Variables are winsorized at the extreme 1%.

[a]Note that the industry-adjusted median is not zero because of the value-weighting procedure.

measure is −0.004, and the median is −0.013, with an interquartile range of 0.169.[16] The values range from −0.415 to 0.557 (see Table 3).

We also create an alternative measure of managerial ability, based on CEO fixed effects, for a sample of 22,982 firm-years with available CEO identifiers. Specifically, we regress firm efficiency on CEO fixed effects. We consider the fitted value of the CEO fixed effects as the lower bound of the manager-specific component of firm efficiency and correlate this predicted value with our residual-based managerial ability measure. The correlation is over 0.80 (see Table 4), which provides a lower-bound estimate of the proportion of the residual that is CEO specific and supports the notion that the residual from Equation (3) is largely attributable to the manager. We opt to focus our analyses on the residual-based measure of managerial ability because it is available for nearly every firm on Compustat, whereas the CEO fixed effects measure is available only for firms covered by Execucomp or Morningstar (limiting both the time and firm coverage), and these fixed effects are uninformative when the executive does not change over the sample period (because firm fixed effects and manager fixed effects are then indistinguishable).

4.4. Comparison with Alternative Ability Measures

In this section, we correlate our proposed measure with five alternative measures of managerial ability used in prior research: historical industry-adjusted stock returns, historical industry-adjusted ROA, CEO compensation, CEO tenure, and media mentions (see §2). We present summary statistics in Table 3 and univariate correlations in Table 4. We also include, in Table 4, correlations for ROA and firm size. First, note the high positive correlation between firm efficiency and managerial ability, which is reasonable given that managerial ability is a component of total firm efficiency, but could also indicate that our partition is imprecise (McNichols 2000). That firm efficiency is also positively correlated with the fitted value of managerial ability suggests that better managers are employed by better firms.

Turning next to the correlations between the DEA-based efficiency measures and the alternative measures of ability, we see that the correlations are reasonably low (all below 0.30), indicating that the DEA-based efficiency measures are different from the alternative ability measures. We also see that these correlations are lower for managerial ability than for firm efficiency, consistent with the removal of many firm-specific characteristics from our managerial ability measure. Only *Media Mentions* does not exhibit the expected positive correlation with managerial ability, although *Media Mentions* and total *Firm Efficiency*

estimate excluding firm fixed effects to maximize comparability across firms, because including firm fixed effects creates a relative ability measure within the firm, but removes important variation across firms (because each firm effectively must have a mean zero efficiency).

[16] The mean is not zero because we estimate Equation (3) using a Tobit regression; we subtract the predicted value from the Tobit estimation from the actual value of *Firm Efficiency* to compute a Tobit "residual." Unlike OLS residuals, which must sum to zero by definition, these computed differences need not. Empirical test results are similar if we use truncated regression or OLS regression to estimate managerial ability, and are also similar if we consider the natural logarithm of total firm efficiency in the OLS estimation.

Table 4 Univariate Correlations

	Firm Efficiency	*Managerial Ability*	*Fitted Value of Ability*	*Historical Return*	*Historical ROA*	Ln(*CEO Cash Compensation*)	Ln(*CEO Tenure*)	Ln(*Media Mentions*)	*ROA*	*Size*
Firm Efficiency		**0.550**	**0.410**	**0.171**	**0.136**	**0.298**	0.011	**0.193**	**0.338**	**0.458**
Managerial Ability	**0.548**		**0.835**	**0.169**	**0.065**	**0.042**	**0.060**	**−0.100**	**0.120**	**0.047**
Fitted Value of Ability	**0.389**	**0.828**		**0.147**	**0.084**	**0.033**	**0.086**	**−0.088**	**0.212**	**0.069**
Historical Return	**0.279**	**0.211**	**0.168**		**0.100**	**0.039**	**0.065**	**−0.025**	**0.236**	**0.176**
Historical ROA	**0.149**	**0.156**	**0.172**	**0.313**		**−0.027**	**0.015**	**0.044**	**0.523**	**0.237**
Ln(*CEO Cash Compensation*)	**0.417**	**0.072**	**0.054**	**0.154**	−0.008		**0.015**	**0.312**	**0.097**	**0.382**
Ln(*CEO Tenure*)	−0.004	**0.056**	**0.086**	**0.116**	**0.071**	**0.028**		−0.009	**0.058**	**−0.030**
Ln(*Media Mentions*)	**0.196**	**−0.092**	**−0.079**	0.006	0.016	**0.435**	**0.030**		**−0.027**	**0.511**
ROA	**0.469**	**0.336**	**0.299**	**0.481**	**0.471**	**0.149**	**0.093**	**−0.102**		**0.231**
Size	**0.459**	**0.066**	**0.095**	**0.318**	**0.405**	**0.568**	**−0.014**	**0.501**	**0.335**	

Notes. This table presents univariate correlations between the main variables used in the tests. *Firm Efficiency* is measured using DEA based on the vectors described in §3.2. *Managerial Ability* is the residual-based measure described in §4.3. *Fitted Value of Ability* is the fitted value of available manager fixed effects on firm efficiency described in §4.3. *Historical Return* is the five-year historical value-weighted industry-adjusted return (from year $t-5$ to year $t-1$). *Historical ROA* is the five-year industry-adjusted return on assets (cumulative income before extraordinary items (IBC) scaled by average total assets (AT) from year $t-5$ to year $t-1$).*CEO Cash Compensation* is the salary and bonus of the firm CEO (TOT_CURR from Execucomp) for year t. *CEO Tenure* is the number of years an executive has been listed as CEO by Execucomp. *Media Mentions* is the number of articles mentioning the CEO over the preceding five-year period. *ROA* is income before extraordinary items (IBC) scaled by average total assets (AT) for year t. *Size* is the natural logarithm of the market value of equity (PRCC_C × CSHO) as of the end of year t. Pearson correlations are presented in the upper right and Spearman correlations are presented in the lower left. Variables are winsorized at the extreme 1%. Bold values indicate statistical significance at the 10% level.

are positively associated.[17] Overall, the evidence indicates that our *Managerial Ability* measure is positively associated with prior measures of managerial ability. These positive correlations hold in the presence of standard control variables (not tabulated).

5. Validation Tests

We hypothesize that our proposed measure reflects managerial ability. We test this hypothesis in three ways. First, we explore whether the measure is economically and significantly associated with manager fixed effects (§5.1). Second, we test whether the measure is negatively associated with the announcement returns to CEO turnovers (§5.2). Third, we investigate whether appointing a relatively more or less able manager is systematically associated with changes in subsequent firm performance (§5.3). For each of these tests, we contrast our measure of managerial ability with the five alternative measures discussed in §4.4.

5.1. Economic Significance of Manager Fixed Effects

To investigate whether manager fixed effects explain an economically significant portion of our managerial ability measure, we conduct a series of tests for a subset of CEOs who switch employers within our sample. By examining CEOs who are present in at least two firms, we can assess whether managerial ability systematically differs across individual CEOs (see, for example, Bertrand and Schoar 2003, Leverty and Grace 2012). To identify this sample, we focus on firms that are both covered by Execucomp or Morningstar and had a change of CEO from 1993 to 2009. We then identify those turnovers where the CEO moved from one sample firm to another during the period 1993 to 2009. We confirm that the CEO did indeed switch firms, versus remaining the CEO of a firm that changed names. We also require that the CEO not switch firms as a result of a merger; following a merger, if the new entity retained either of the preexisting CEOs, we exclude this observation. Finally, we require that the CEO hold his or her post for two years in each firm to allow the CEO time to affect the firm. Our final sample contains 78 CEOs employed by 125 unique firms.

We regress our managerial ability measure on manager and firm fixed effects and expect manager fixed effects to explain a greater proportion of the variation in our ability measure than firm fixed effects. We examine the proportion of fixed effects that are statistically significant; we again cluster standard errors by firm and year. Following Leverty and Grace (2012), we use the estimation with year fixed effects as the benchmark specification. As Table 5 shows, we find that 66.5% of the manager fixed effects are statistically significant ($p < 0.10$, two-tailed) when firm fixed effects are omitted, whereas 60.5% of manager fixed effects remain significant when firm fixed effects are included. In contrast, only 29.1% of firm fixed effects are statistically significant. This suggests that our managerial ability measure is more attributable to the CEO than to the firm.

[17] Note that the correlation is positive in Baik et al. (2011); however, their sample is constrained to large firms with Execucomp and First Call coverage, and it is likely that larger firms garner more media attention, holding managerial ability constant.

Table 5 Manager and Firm Fixed Effects

	Dependent variable = *Ability Measure*			
Ability measure	Fixed effect	Proportion significant (%)		Spread (manager-firm) (%)
Managerial Ability	Manager	66.5	60.5	31.4
	Firm		29.1	
Historical Return	Manager	48.1	26.9	7.5
	Firm		19.4	
Historical ROA	Manager	47.3	29.0	−3.6
	Firm		32.6	
Ln(*CEO Cash Compensation*)	Manager	69.7	42.7	4.2
	Firm		38.5	
Ln(*Tenure*)	Manager	52.9	75.6	3.2
	Firm		72.4	
Ln(*Media Mentions*)	Manager	47.6	42.7	−0.7
	Firm		43.4	

Notes. This table provides statistics on the economic significance of individual managers on six ability measures. To be included, a CEO must be employed as CEO by at least two companies in the sample from 1993–2009. There are a maximum of 78 CEOs from 125 firms, although for some measures there will be fewer observations because of data availability. Each regression includes year fixed effects and the natural logarithm of total assets to control for size. The ability measure is the dependent variable, and we estimate two specifications: with manager fixed effects (1st column) and with manager and firm fixed effects (2nd column). The proportion significant is determined based on robust t-statistics, with standard errors clustered by firm and year ($p < 0.10$). Spread is the difference in the proportion of manager and firm fixed effects achieving statistical significance. *Managerial Ability* is the residual-based measure described in §4.3. *Historical Return* is the five-year historical value-weighted industry-adjusted return (from year $t-5$ to year $t-1$). *Historical ROA* is the five-year industry-adjusted return on assets (cumulative income before extraordinary items (IBC) scaled by average total assets (AT) from year $t-5$ to year $t-1$). *CEO Cash Compensation* is the salary and bonus of the firm CEO (TOT_CURR from Execucomp) for year t. *CEO Tenure* is the number of years an executive has been listed as CEO by Execucomp. *Media Mentions* is the number of articles mentioning the CEO over the preceding five-year period.

We conduct a similar examination of the proportion of significant manager and fixed effects for each of the alternative measures of ability, also presented in Table 5. The proportion of significant manager fixed effects varies from 26.9% (*Historical ROA*) to 75.6% (*Compensation*) when firm fixed effects are included, consistent with these measures also containing a manager-specific component. The spread between the proportion of manager and firm fixed effects ranges from 7.5% (*Compensation*) to −3.6% (*Industry-Adjusted ROA*), which are far below the range of 31.4 for our ability score.

5.2. Price Reactions to Turnovers

To further investigate the extent to which our proposed measure reflects managerial ability, we examine the association between the score and announcement returns to CEO turnovers. We identify 1,450 firm-year observations where the CEO left the firm after serving in that role for at least three years and where we can determine the price reaction to the announcement of the turnover; we require that the firm have both CRSP data and an 8-K filing date announcing the turnover (available from Audit Analytics since 2000; generally the 8-K filings are an upload of the press release issued announcing the turnover). We accumulate the corresponding stock price reactions across two aggregation periods $(-1,1$ and $-5,1)$. We consider the six-day window because the press release announcing the CEO turnover can be issued up to four days before the filing of the 8-K. We use the announcement return as a proxy for the market's assessment of the departing manager's ability. We expect the turnover announcements of outgoing managers with low (high) ability to be associated with positive (negative) price reactions.

We present the results in Table 6; we regress the announcement return on managerial ability and again cluster standard errors by firm and year. Consistent with our proposed measure reflecting, at least in part, managerial ability, we find that the turnover announcements are negatively associated with the CEO's ability score. The coefficient on managerial ability is negative and significant. In terms of economic significance, a one-standard-deviation shift in manager ability is associated with returns of −0.37% and −0.44% for the $(-1,1)$ and $(-5,1)$ windows, respectively. These marginal effects represent 7.3% (5.3%) of the interquartile range for the shorter (longer) return window, and thus appear to be economically significant.

To contrast our ability measure with alternative measures, we examine whether a similar relation exists for the alternative ability proxies. Consistent with prior research (e.g., Johnson et al. 1985, Warner et al. 1988), we find no evidence of a negative relation between turnover announcement returns and any of the alternative proxies. Interestingly, the coefficient on CEO pay is positive, which is the opposite of the predicted sign, consistent with CEO entrenchment leading to overpaid CEOs.

These findings suggest that our ability measure has a manager-specific element that is valued by the market and provides preliminary evidence that it outperforms other ability proxies on this dimension. The reason for the insignificance on the alternative proxies, however, is unclear. Although we argue in this paper that our measure outperforms these other measures, it is also possible that the alternative measures would perform equally well given sufficient power, or perhaps alternative subsamples. To explore this, in panel B of Table 6 we reexamine the announcement returns using our ability score, but for the alternative subsamples. The five columns use the subsample of the five alternative proxies (e.g., the first column of

Table 6 Stock Price Reactions to CEO Turnovers

Panel A: Main analysis

Dependent variable = *Announcement Return*

	Ability measure											
	Managerial Ability		*Historical Return*		*Historical ROA*		Ln(*CEO Cash Compensation*)		Ln(*Tenure*)		Ln(*Media Mentions*)	
	(−1, 1)	(−5, 1)	(−1, 1)	(−5, 1)	(−1, 1)	(−5, 1)	(−1, 1)	(−5, 1)	(−1, 1)	(−5, 1)	(−1, 1)	(−5, 1)
Return	−0.024**	−0.028**	−0.001	−0.001	−0.001	−0.000	0.002††	0.004††	0.002	0.000	0.001	0.001
(*t*-statistic)	(−2.13)	(−2.05)	(−1.63)	(−1.58)	(−0.47)	(−0.14)	(2.06)	(2.03)	(1.45)	(0.05)	(0.71)	(0.47)
Marginal Effect	−0.0037	−0.0044	−0.0019	−0.0020	−0.0010	−0.0002	0.0023	0.0044	0.0024	0.0002	0.0013	0.0015
Observations	2,229		1,604		1,883		879		855		454	

Panel B: Subsample tests

Dependent variable = *Announcement Return*

	Subsample									
	Historical Return		*Historical ROA*		Ln(*CEO Cash Compensation*)		Ln(*Tenure*)		Ln(*Media Mentions*)	
	(−1, 1)	(−5, 1)	(−1, 1)	(−5, 1)	(−1, 1)	(−5, 1)	(−1, 1)	(−5, 1)	(−1, 1)	(−5, 1)
Managerial Ability	−0.032***	−0.033***	−0.028	−0.033**	−0.002	−0.003	−0.003	−0.006	0.002	0.004
(*t*-statistic)	(−2.60)	(−2.43)	(−1.46)	(−2.14)	(−0.13)	(−0.66)	(−0.17)	(−0.88)	(0.07)	(0.33)
Marginal Effect	−0.0050	−0.0052	−0.0044	−0.0052	−0.0003	−0.0005	−0.0005	−0.0009	0.0003	0.0006
Observations	1,604		1,883		879		855		454	

Notes. This table presents results on short-window returns following the announcement of CEO turnovers. *Managerial Ability* is the residual-based measure described in §4.3. *Historical Return* is the five-year historical value-weighted industry-adjusted return (from year $t-5$ to year $t-1$). *Historical ROA* is the five-year industry-adjusted return on assets (cumulative income before extraordinary items (IBC) scaled by average total assets (AT) from year $t-5$ to year $t-1$). *CEO Cash Compensation* is the salary and bonus of the firm CEO (TOTAL CURR from Execucomp) for year t. *Tenure* is the number of years an executive has been listed as CEO on Execucomp. *Media Mentions* is the number of articles mentioning the CEO over the preceding five-year period. In panel A we present the OLS regression coefficient on the ability measure on short-window returns of three and six days. We present the coefficient, robust *t*-statistics with standard errors clustered by firm and year, and marginal significance (the difference in return for a one-standard-deviation change in ability measure). In panel B we present regressions for subsamples where the specified variable is not missing; *Managerial Ability* is the independent variable in each regression. Variables are winsorized at the extreme 1%.

**5% and ***1% statistical significance (two-tailed tests); ††5% statistical significance (two-tailed tests) in the direction opposite to predictions.

results is estimated within the 1,604 observations that have historical return data). We find similar results within the two largest subsamples (historical returns and historical ROA), suggesting that our ability score does outperform these two alternative measures in this setting. The results within the latter three subsamples, however, are insignificant.

It is possible that these tests lack power, either because of the reduced sample size or because of systematic differences between the subsamples and the underlying population. Specifically, because the latter three samples tend to contain larger firms, on average, than the full population for which we calculated managerial ability, it may be that there is less variation in the measured managerial ability of these subsamples, leading to low power tests. We conduct several additional analyses in an effort to determine if one or both of these explanations is valid. First, we reestimate the six-day announcement return on our managerial ability score for 100 random draws of 879 and 454 observations from the sample of 2,229 observations in panel A. Although the bulk of these are insignificant, consistent with sample size lowering the power of these tests, the average coefficients on these estimations are −0.028 and −0.029 for the compensation and media mention samples, respectively. We compare these to the coefficients in panel B of 0.003 (compensation), −0.006 (tenure), and 0.004 (media cites) and reject the null that they are drawn from the same distribution with *t*-statistics of −2.40, −1.69, and −1.65, respectively. Thus, although sample size is clearly playing a role, the insignificance in panel B is at least partly due to the underlying population examined. Thus, we cannot yet conclude that our measure dominates compensation, tenure, and media mentions, because it could be that these subsamples simply lack variation in ability. To investigate this, we next reestimate managerial ability for only those firms that have media mention data (by first estimating firm efficiency using DEA and then reestimating Equation (3) to extract firm characteristics, again, only for the media mention subsample).

When we reexamine the relation between announcement returns and managerial ability, we obtain a coefficient of −0.018 and a *t*-statistic of −1.35, both of which are much more in line with the statistics obtained in our bootstrapping analysis. Thus, users of our managerial ability score will need to reestimate DEA within the population of firms they wish to examine if their sample of interest is both sufficiently small and systematically different from the total population.

5.3. Transferability of Ability: Changes in Firm Performance Following New Appointments

As a final validity test, we investigate whether a newly appointed CEO's prior ability score (estimated while employed at the prior firm) is correlated with the subsequent performance of the new firm. We expect that firms hiring better (worse) managers experience improvements (declines) in firm performance. For the 78 CEOs who were employed by more than one firm in our sample, we calculate the difference in CEO ability by subtracting the outgoing managers' ability from the incoming managers' ability (measured in their prior firm). We regress both subsequent industry-adjusted stock returns and subsequent changes in industry-adjusted ROA on the ability difference. As before, we cluster standard errors by firm and year.

Table 7 presents the results. Consistent with our expectations, we find evidence of improved performance in the three years following the appointment of a higher-ability CEO. For example, a one-standard-deviation increase in the relative ability of a CEO is associated with a 37.0% higher stock return and 3.2% higher ROA over the next three years; these changes represent 57% and 34% of the interquartile range for returns and ROA, respectively. These results are especially compelling because they are based on the newly appointed CEOs' ability from their prior firms, and thus are less subject to the concern that the residual-based ability measure reflects other unidentified firm characteristics. Using this measure, there is strong evidence that managers' assessed levels of ability transfer across firms and explain future performance at their new firm.

We again replicate the analysis for the alternative ability measures. None of the alternative measures explains subsequent returns, but both historical industry-adjusted ROA and CEO tenure are positively associated with changes in future industry-adjusted ROA. To assess the underlying reason for the insignificant results for the alternative measures, we again reestimate our main results for each of the subsamples in Table 7, panels C and D, respectively. In panel C, changes in our ability score are associated with changes in industry-adjusted stock returns for four of the five samples (all but media mentions), whereas in panel D, changes in our ability score are associated with changes in industry-adjusted ROA in only the two largest samples. As in Table 6, it is likely that the power of the test is limited among the smaller samples because of both sample size and systematically different underlying populations. To investigate this, we again reestimate the analysis using managerial ability estimated within the media mention subsample. As before, results strengthen considerably; we document positive coefficients on managerial ability for both estimations (with *t*-statistics of 2.20 and 1.61 for industry-adjusted returns and industry-adjusted ROA, respectively; not tabulated).

To summarize, we conclude that although it contains noise, our managerial ability measure offers a cleaner depiction of managers' ability than prior measures. It is economically and significantly associated with manager fixed effects and is associated with both the price reactions to CEO turnover announcements and changes in firm performance following new CEO appointments.

6. Managerial Ability and the New Issue Puzzle

In this section, we demonstrate the potential of our measure to resolve extant research puzzles. Firms issuing seasoned equity have inordinately low stock returns during the five years after the offering (Loughran and Ritter 1995). Investigating this puzzle, Loughran and Ritter (1997) find that firms that rapidly increase either sales or capital expenditures have lower subsequent stock returns than other firms. After controlling for growth, however, they continue to find that issuing firms substantially underperform nonissuers and suggest that the firms are investing in what the market views as positive net present value projects, when often these projects have negative net present values. Moreover, even in the face of deteriorating performance, they find that managers continue to invest heavily, suggesting that the managers are also overoptimistic about the issuing firms' future profitability.

We conjecture that superior managers are better able to effectively select and execute positive net present value projects, and are less likely to allow unrealistic expectations to cloud their decision making. Thus, we expect the negative relation between equity financing and subsequent abnormal returns to be mitigated in firms with better managers. Regression results are presented in panel A of Table 8; as in prior estimations, we cluster standard errors by firm and year. Similar to Bradshaw et al. (2006), we measure equity financing as the change in equity (Compustat: "CEQ") plus the change in

Table 7 Performance Changes Following Management Changes

Panel A: Change in stock return

Dependent variable = *Change in Industry-Adjusted Stock Return*

		Ability measure					
	Predicted sign	*Managerial Ability*	*Historical Return*	*Historical ROA*	Ln(*CEO Cash Compensation*)	Ln(*Tenure*)	Ln(*Media Mentions*)
Difference in Ability	+	2.817***	−0.036	−0.047	−0.281††	−0.066	−0.098
		(2.76)	(−0.39)	(−0.43)	(−2.05)	(−0.50)	(−0.88)
Control variables for the CEO's new firm							
Change in ROA	+	1.646***	0.941**	0.764*	0.208	0.942*	2.037***
		(3.29)	(1.96)	(1.75)	(0.49)	(1.64)	(5.04)
Change in Book-to-Market	?	−0.154	−0.457**	−0.746***	−0.979***	−0.826***	−0.039
		(−1.25)	(−2.13)	(−2.47)	(−4.26)	(−2.72)	(−0.28)
Change in Ln(*Market Value of Equity*)	?	−0.501***	−0.345***	−0.325**	−0.256*	−0.382*	−0.055
		(−2.49)	(−3.16)	(−2.32)	(−1.20)	(−1.95)	(−0.21)
Intercept		0.057	0.075	0.116	0.199	0.102	−0.073
		(0.42)	(0.58)	(1.05)	(1.12)	(0.76)	(−0.43)
Observations		78	68	74	50	69	31
Adjusted R^2		0.25	0.24	0.23	0.33	0.20	0.63

Panel B: Change in ROA

Dependent variable = *Change in Industry-Adjusted ROA*

		Ability measure					
	Predicted sign	*Managerial Ability*	*Historical Return*	*Historical ROA*	Ln(*CEO Cash Compensation*)	Ln(*Tenure*)	Ln(*Media Mentions*)
Difference in Ability	+	0.245**	0.011	0.028*	0.033	0.036**	0.019
		(3.14)	(0.72)	(0.98)	(1.09)	(1.96)	(0.19)
Control variables for the CEO's New Firm							
Change in Stock Return	+	0.042***	0.068***	0.051***	0.032	0.041**	0.329**
		(3.55)	(3.19)	(3.04)	(1.33)	(2.28)	(2.13)
Change in Book-to-Market	?	0.005	−0.023	−0.011	−0.035	−0.017	−0.019
		(0.14)	(−0.47)	(−0.24)	(−0.70)	(−0.39)	(−0.20)
Change in Ln(*Market Value of Equity*)	?	0.024	0.027	0.025	0.016	0.034*	0.026
		(0.91)	(0.95)	(0.96)	(0.20)	(1.41)	(0.38)
Intercept		0.002	0.010	−0.001	0.001	−0.024	0.028
		(0.13)	(0.53)	(−0.06)	(0.03)	(−1.20)	(0.45)
Observations		78	68	74	50	69	31
Adjusted R^2		0.07	0.14	0.11	0.07	0.13	0.53

Panel C: Change in Stock Return

Dependent variable = *Change in Industry-Adjusted Stock Return*

		Subsample				
	Predicted sign	*Historical Return*	*Historical ROA*	Ln(*CEO Cash Compensation*)	Ln(*Tenure*)	Ln(*Media Mentions*)
Difference in Ability	+	1.490*	1.699**	1.671**	2.910***	1.100
		(1.71)	(2.37)	(2.06)	(3.08)	(0.50)
Control variables for the CEO's new firm						
Change in ROA	+	0.968*	0.980*	0.460	1.483**	2.258***
		(1.78)	(1.72)	(0.67)	(2.09)	(3.93)
Change in Book-to-Market	?	−0.472***	−0.598***	−0.745***	−0.524**	−0.027
		(−2.46)	(−2.94)	(−3.15)	(−2.07)	(−0.10)
Change in Ln(*Market Value of Equity*)	?	−0.379***	−0.348***	−0.326**	−0.413***	0.022
		(−3.58)	(−3.07)	(−2.31)	(−2.95)	(0.10)
Intercept		0.068	0.060	0.168	−0.006	−0.140
		(0.72)	(0.60)	(1.32)	(−0.05)	(−0.86)
Observations		68	74	50	69	31
Adjusted R^2		0.23	0.28	0.35	0.30	0.61

Table 7 (Continued)

Panel D: Change in ROA

Dependent variable = *Change in Industry-Adjusted ROA*

	Predicted sign	Subsample				
		Historical Return	*Historical ROA*	Ln(*CEO Cash Compensation*)	Ln(*Tenure*)	Ln(*Media Mentions*)
Difference in Ability	+	0.226***	0.261***	0.134	0.290	0.668
		(2.52)	(2.77)	(0.80)	(1.50)	(0.82)
Control variables for the CEO's New Firm						
Change in Stock Return	+	0.066***	0.050***	0.028	0.043***	0.315***
		(3.13)	(2.60)	(1.16)	(2.71)	(3.66)
Change in Book-to-Market	?	−0.010	−0.003	−0.046	−0.021	0.021
		(−0.28)	(−0.09)	(−1.15)	(−0.61)	(0.21)
Change in Ln(*Market Value of Equity*)	?	0.037*	0.026	0.022	0.037**	−0.019
		(1.88)	(1.35)	(0.95)	(1.96)	(−0.22)
Intercept		0.006	0.000	−0.000	−0.005	0.046
		(0.35)	(0.02)	(−0.00)	(−0.20)	(0.73)
Observations		68	74	50	69	31
Adjusted R^2		0.12	0.07	0.05	0.10	0.57

Notes. The two dependent variables are the *Change in Industry-Adjusted Stock Return* and the *Change in Industry-Adjusted ROA*, where changes are measured as the value in year $t+3$ less the value in year $t-1$, where both values are measured at the new firm. The differences in the six ability measures are calculated across firms and are equal to the CEO's prior ability less the outgoing CEO's ability. The six ability measures considered are *Managerial Ability*, the residual-based measure described in §4.3 (measured in year $t-1$); *Historical Return*, the five-year historical value-weighted industry-adjusted return (from year $t-5$ to year $t-1$); *Historical ROA*, the five-year industry-adjusted return on assets (cumulative income before extraordinary items (IBC) scaled by average total assets (AT) from year $t-5$ to year $t-1$); *CEO Cash Compensation*, the salary and bonus of the CEO (TOT_CURR from Execucomp) in year $t-1$; *CEO Tenure*, the number of years an executive has been listed as CEO by Execucomp as of year $t-1$; and *Media Mentions*, the number of articles mentioning the CEO from year $t-5$ to year $t-1$. Changes in control variables are measured as year $t+3$ less year $t-1$, where both values are measured at the new firm. Control variables are *ROA*, income before extraordinary items (IBC) scaled by average total assets (AT); *Book-to-Market*, the beginning of year book value of equity (CEQ) divided by *Market Value of Equity*; and *Market Value of Equity*, the beginning of year equity capitalization (PRCC_C × CSHO). Variables are winsorized at the extreme 1%. Robust *t*-statistics, with standard errors clustered by firm and year, are presented in parentheses.

*10%, **5%, and ***1% statistical significance (two-tailed tests); ††5% statistical significance (two-tailed tests) in the direction opposite to predictions.

preferred stock ("PSTK") minus net income ("NI"). We measure future abnormal returns as the value-weighted industry-adjusted annual return beginning four months after year-end. We regress the future, post-equity-issue returns on the change in equity financing, our measure of managerial ability, and the interaction of these two variables. Consistent with Loughran and Ritter (1995) and Bradshaw et al. (2006), we find a negative coefficient on the equity financing variable, indicating that higher levels of equity financing result, on average, in lower future returns. The coefficient on managerial ability is positive, indicating that more talented managers, as defined by our measure, are associated with higher future returns. Finally, there is also a positive coefficient on the interaction term of equity financing and ability, our variable of interest, suggesting that more able managers mitigate the negative association between external financing and future abnormal returns. The incremental effects are −0.063 and 0.085 for the best and worst manager, respectively, where the best (worst) manager has an ability score of 0.557 (−0.415) (see Table 3). As in the prior tests, our managerial ability measure outperforms other proxies of ability, with only historical returns loading weakly in the predicted direction.[18]

In panel B of Table 8, we again investigate the underlying reason for insignificance for the alternative ability proxies by reestimating our main analysis for each of the subsamples. Consistent with the results in panel A, we find that managerial ability continues to mitigate the future abnormal returns associated with equity issuances for each of these subsamples. This finding is important because it allows us to conclude that our measure does dominate the

[18] We further corroborate these results by exploring the association between managerial ability and growth opportunities (e.g., Chemmanur and Paeglis 2005, Jones and Olken 2005). We expect more able managers to successfully identify and capitalize on investment opportunities, and thus we expect our managerial ability measure to be associated with Tobin's q, a measure of investment opportunities, defined as the market value of assets (market value of equity plus the book value of long-term debt ((PRCC_C × CSHO) + (DLTT + DLC)) divided by total assets (AT). In untabulated results, we find that more able managers have higher Tobin's q. Moreover, this association persists in the presence of the alternative measures of managerial ability examined previously. In terms of economic significance, a one-standard-deviation increase in managerial ability is associated with a 10.6% higher Tobin's q after we control for annual return, sales growth, and market value of equity.

Table 8 New Issue Puzzle

Panel A: Comparison of ability measures

Dependent variable = *Future Returns*

	Predicted sign	Ability measure					
		Managerial Ability	*Historical Return*	*Historical ROA*	Ln (*CEO Cash Compensation*)	Ln(*Tenure*)	Ln(*Media Mentions*)
Change in Equity	−	−0.057	−0.088*	−0.035**	0.329†††	0.094†	0.575†††
		(−1.22)	(−1.89)	(−2.10)	(3.07)	(1.65)	(3.22)
Ability Measure	+	0.219***	0.042***	0.039**	0.040***	0.005*	0.017***
		(7.14)	(11.06)	(2.10)	(3.07)	(1.65)	(3.41)
Change in Equity × *Ability Measure*	+	0.153**	0.015	−0.011	−0.020	0.060	−0.082††
		(1.97)	(0.91)	(−1.33)	(−0.22)	(0.91)	(−2.48)
Ln(*Market Value of Equity*)	−	−0.022***	−0.028***	−0.026***	−0.048***	−0.035***	−0.065***
		(−3.53)	(−4.56)	(−4.73)	(−4.96)	(−4.07)	(−6.47)
Book-to-market	+	−0.074†††	−0.051†††	−0.071†††	−0.115†††	−0.109†††	−0.153†††
		(−4.95)	(−4.19)	(−4.90)	(−3.68)	(−3.55)	(−3.59)
Intercept		0.289***	0.214***	0.296***	0.205***	0.369***	0.519***
		(9.79)	(7.15)	(10.27)	(3.50)	(7.69)	(8.43)
Observations		112,550	76,155	88,083	20,423	19,005	13,974
Year indicators		Included	Included	Included	Included	Included	Included
Adjusted R^2		0.05	0.08	0.05	0.06	0.06	0.07

Panel B: Subsample Tests

Dependent variable = *Future Returns*

	Predicted sign	*Historical Return Sample*	*Historical ROA Sample*	*Compensation Sample*	*Tenure Sample*	*Media Mentions Sample*
Change in Equity	−	−0.056	−0.036	0.170	0.166	0.212
		(−1.16)	(−0.66)	(0.96)	(0.90)	(0.98)
Managerial Ability	+	0.191***	0.181***	0.034	0.023	0.045
		(5.64)	(5.15)	(0.76)	(0.53)	(0.74)
Change in Equity × *Managerial Ability*	+	0.114*	0.113*	0.444*	0.440**	0.484**
		(1.65)	(1.64)	(1.89)	(2.03)	(2.14)
Ln(*Market Value of Equity*)	−	−0.023***	−0.022***	−0.038***	−0.036***	−0.060***
		(−3.66)	(−3.63)	(−4.40)	(−4.12)	(−6.39)
Book-to-Market	+	−0.066†††	−0.064†††	−0.115†††	−0.111†††	−0.153†††
		(−4.66)	(−4.27)	(−3.52)	(−3.43)	(−3.48)
Intercept		0.283***	0.272***	0.518***	0.508***	0.522***
		(9.15)	(8.47)	(7.73)	(7.67)	(8.34)
Observations		76,155	88,083	20,423	19,005	13,974
Year indicators		Included	Included	Included	Included	Included
Adjusted R^2		0.05	0.05	0.06	0.06	0.07

Notes. This table presents results on the relation between external financing and managerial ability. *Future Returns* is the value-weighted industry-adjusted return for the year following the measurement of change in equity and ability. *Managerial Ability* is the residual-based measure described in §4.3. *Change in Equity* is the change in equity financing, defined as the change in equity (CEQ) plus the change in preferred stock (PSTK) less net income (NI) scaled by average total assets (AT). Panel A presents regression results for *Managerial Ability* and five other ability measures. Panel B presents regression results for our managerial ability score restricting the sample to those used by the alternative ability measures in panel A. Variables are winsorized at the extreme 1%. Robust *t*-statistics, with standard errors clustered by firm and year, are presented in parentheses.

*10%, **5%, and ***1% statistical significance (two-tailed tests); †10%, ††5%, and †††1% statistical significance (two-tailed tests) in the direction opposite to predictions.

alternative ability metrics—even absent its calculation within specific subsamples—if sample size is sufficiently large. As noted previously, however, if the subsamples are too small and the underlying distribution differs from the population over which our ability score is estimated, the score's explanatory power is limited. Thus, in some analyses, researchers may need to reestimate ability within their desired subsample.

To summarize, we demonstrate the usefulness of our managerial ability measure in resolving research puzzles by focusing on the finding of underperformance following seasoned stock issues. We document that firms that take on high levels of equity financing

tend to have lower returns in the future; however, these low returns are substantially mitigated when the equity is issued by more talented managers who appear more able to identify and execute positive net present value projects and thus use the issue proceeds more effectively. This illustrates one of many potential applications for our measure of managerial ability.

7. Conclusion

Research on managerial ability is active across many disciplines and uses multiple proxies for talent, but all are affected to some extent by intervening factors such as firm and industry attributes. We advance a more precise measure of managerial ability that is available for a large sample of firms and is comparable across industries.

Using data envelopment analysis as a platform to estimate firm efficiency, we quantify managerial ability by distinguishing between managerial talent and a number of firm-driven effects on firm efficiency. We validate our managerial ability measure by showing that (1) it has an economically significant association with manager fixed effects, (2) it is negatively associated with the price reactions to CEO turnover announcements, and (3) it is positively associated with the subsequent performance at CEOs' new appointments (where the score is measured in their prior firms). Moreover, our ability measure outperforms alternative ability measures on each of these dimensions. Finally, to illustrate the usefulness of our measure, we document that managerial ability mitigates the negative association between equity financing and future abnormal returns, a known puzzle in the finance literature.

The measure of managerial ability, although an improvement over current measures, has limitations. First, there is measurement error in the inputs and output to firm efficiency; some accounting variables contain measurement error, whereas others are unavailable. In addition, our second stage dampens variation in ability, for example, by controlling for firm size, because better managers are more likely to be hired by larger firms (Rosen 1982). Future researchers can expand the input and/or output sets or the second-stage estimation to create a more refined measure. Second, the measure is the residual from a model; however, a portion of this residual reflects factors that are not attributable to managerial ability. In robustness checks, we estimate the variable as a fitted value based on CEO fixed effects. This measure has a correlation of 0.835 with the managerial ability measure presented, providing a lower bound of the proportion of the score attributable to the manager. Another limitation is that our ability score is estimated over a broad population, and thus, when the sample of interest has a different underlying distribution, the score's explanatory power is limited. Thus, in some analyses, researchers may need to reestimate ability within their desired subsample. Finally, some of the DEA input variables, such as *Net PP&E*, were determined by both the current manager and past managers, and thus the score is truly of both the current and past management teams. Future studies requiring an ability score for managers with fewer years of history might adapt the inputs to only those that can be changed in the short term, and instead control for the longer-term inputs that are more difficult to change.

Despite these limitations, our measure of managerial ability is available for a broad cross section of firms, exhibits an economically significant manager-specific component, and contains less noise than existing proxies of managerial ability. Future researchers who use our measure or variations thereof may consider questions like whether better managers make superior dividend or share repurchase decisions, whether better managers select and execute higher-quality corporate acquisitions (e.g., Leverty and Qian 2011) or issue higher quality disclosures (e.g., Baik et al. 2011), whether managers behave as if they are able to gauge their own ability, or whether the board of directors and the market accurately price managerial ability (through compensation and stock price). And more fundamentally, what determines managerial ability (e.g., education, experience, social connections; Kaplan et al. 2012)? In sum, a more precise and more widely available measure of managerial ability will allow us to expand our knowledge of the specific role of management in the efficient allocation of resources.

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