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Deviations from optimal CEO ownership and firm value

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ABSTRACT

The transaction cost theory of managerial ownership and firm value predicts that deviations from optimal managerial ownership reduce firm value. This paper empirically tests the transaction cost theory by studying the relation between deviations on either side of optimal CEO ownership and firm value. We find that both above-optimal and below-optimal deviations reduce firm value. We find that a change in CEO ownership is associated with a higher (lower) abnormal return if it moves the ownership towards (away from) the optimal level. These findings are consistent with the transaction cost theory of managerial ownership and firm value.

1. Introduction

The relation between managerial ownership and firm value has received considerable attentions from economists. Two main schools of thought exist with different starting points. One assumes that managerial ownership is exogenously determined, while the other assumes that it is endogenously determined. Regarding the exogenous assumption, Morck et al. (1988) and McConnell and Servaes (1990) find a significant non-linear relation between managerial ownership and firm value, and argue that it is consistent with both the incentive alignment hypothesis (e.g., Jensen and Meckling, 1976) and the managerial entrenchment hypothesis (e.g., Stulz, 1988). Regarding the endogenous assumption, Demsetz and Lehn (1985) and Himmelberg et al. (1999) find that the empirical relation between managerial ownership and firm value is insignificant. They argue that this finding is consistent with the interpretation that firms optimally choose managerial ownership to maximize their value. In that case, no empirical relation between managerial ownership and firm value reflects the equilibrium outcome. As suggested by Core and Larcker (2002), the essential difference between these two viewpoints is the assumption regarding the adjustment costs required to correct sub-optimal contracts.

Core and Larcker (2002) try to reconcile these two schools of thought, and propose a transaction cost theory of managerial ownership and firm value.[1] They begin with an assumption that adjustment costs are neither too large nor too small, so that firms only conduct periodic re-contracting: Firms choose optimal managerial ownership when they contract, but managerial ownership can deviate from the optimal level after contracting; as a result, firms periodically re-optimize managerial ownership. A hypothesis arises from this assumption: Deviations from an endogenously determined optimal managerial ownership level to a sub-optimal level can reduce firm value. The transaction cost theory links the two stands in the literature, and is complementary to the theories that identify actual reasons and mechanisms by which managerial ownership affects firm value (e.g., Jensen and Meckling, 1976; Stulz, 1988).

The motivation of this paper is to test the transaction cost theory of managerial ownership and firm value by studying the relation between deviations on either side of optimal CEO ownership and firm value. It is important to study the deviations on either side of optimal ownership when one attempts to test the theory. Generally, Core and Larcker find an increasing relation between managerial ownership and firm value, and claim that the results support the transaction cost theory. However, their results can be interpreted in another way because they are also consistent with the incentive alignment hypothesis proposed by Jensen and

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[1] One may wonder what transaction costs are actually involved in adjusting ownership. Cheung and Wei (2006) argue that some of the impediments to quick adjustment to ownership levels are legal restrictions on insider trading, corporate restrictions on insider trading, short selling constraint, information asymmetry, and insider's market timing.

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Meckling that predict a strictly increasing relation between ownership and firm value. To avoid the ambiguity, we need to test the predictions on both above-optimal and below-optimal deviations that derive from the transaction cost theory.

We use a sample of 6348 firm-year observations from 1995 to 2000. We focus on CEO ownership in this study. Motivated by the methodology in Core and Guay (1999), we use a regression to estimate the determinants of CEO ownership, and obtain the residuals in the regression as the measure of deviations from the optimum. Since the residuals can be either positive or negative, they correspond with both above-optimal and below-optimal deviations.

We first study the relation between deviations and the level of firm value. We find that deviations on either side of optimal CEO ownership reduce Tobin's Q. Next we study the relation between deviations and the change in firm value. We examine two events that change CEO ownership: sales and purchases of shares by CEOs. McConnell et al. (2005) examine the change in insider ownership and the change in firm value in the research setting of purchases of shares by insiders. Our paper complements theirs in that we consider both purchases and sales of shares and focus on the CEO. We find that a change in CEO ownership is associated with a higher (lower) abnormal return if it moves the ownership towards (away from) the optimal level. The results imply that market reactions correspond with how an event changes the deviations, supporting the interpretation that deviations on either side of optimal CEO ownership reduce firm value.

We conclude that the results in this paper are consistent with the transaction cost theory of managerial ownership and firm value, and that they reconcile the contrasting predictions and findings of Morck et al. (1988) and Demsetz and Lehn (1985).

The paper is organized as follows. Section 2 describes the sample and the variables. Section 3 describes the methodology used to obtain the measures of deviations from optimal CEO ownership. Section 4 examines the relation between deviations and the level of firm value. Section 5 examines the relation between deviations and the change in firm value. Section 6 concludes the paper.

2. Sample and variables

We obtain CEO stock and option holdings data from Execucomp. We use balance sheet data from Compustat and stock return data from CRSP. We use a sample of balanced panel data in the analysis, because the transaction cost theory of ownership and firm value can be viewed as a target-adjustment model where CEO ownership is periodically adjusted to the optimal level. This follows the literature of capital structure where balanced panel data are used in target-adjustment tests (e.g., Jalilvand and Harris, 1984; Titman and Wessels, 1988; Auerbach, 1985; Shyam-Sunder and Myers, 1999). We use a sample of firms that are continuously available in Execucomp from 1995 to 2000. We also exclude financial firms (SIC 6000-6999) and the firms with incomplete data. After these screening procedures, we obtain a final sample of 1058 firms with 6348 firm-year observations.

2.1. Firm value

We use Tobin's Q as the measure of firm value calculated as the market value of equity minus the book value of equity plus the book value of assets, divided by the book value of assets. In Section 5, we study how deviations from optimal ownership affect the change in firm value by using two event studies. We use the cumulative abnormal return over days (−10,+10) around the event date as the measure of the change in firm value.

2.2. CEO ownership

We follow Core and Guay (1999) and define CEO ownership as the sum of the proportion of shares outstanding held by a CEO plus the proportion of shares outstanding in options held by the CEO times the Black–Scholes hedge ratio (the delta):

$$\text{CEO Ownership} = \frac{\#\text{Shares Held by CEO}}{\#\text{Diluted Shares Outstanding}} + \frac{\#\text{Options Held by CEO}}{\#\text{Diluted Shares Outstanding}} * \text{delta} \quad (1)$$

$$\text{with delta} = \frac{\partial(\text{Black—Scholes option value})}{\partial\text{Stock price}} = e^{-dT} * N(Z), \quad (2)$$

$$Z = [\log(S/X) + T(r - d + \sigma^2/2)]/\sigma T^{(1/2)}, \quad (3)$$

where N is the cumulative probability function for the normal distribution; S is the price of the underlying stock; X is the exercise price of the option; σ is the expected stock return volatility over the life of the option; r is the risk-free interest rate; T is the time to maturity of the option in years; and d is the expected dividend yield over the life of the option.

As detailed in Appendix B, we use the methodology in Core and Guay (1999, 2002) to calculate this measure.

2.3. Control variables

Control variables are used to measure exogenous parameters in a firm's contracting environment. These variables are related to potential moral hazard and monitoring difficulty. Himmelberg et al. (1999) argue that a large part of the parameters are unobservable. It is therefore important to control for both unobservable and observable firm characteristics in the underlying contracting environment. We use a firm fixed effect regression that can control for unobservable firm characteristics as long as they are stable over time. Motivated by Himmelberg et al., we include the following additional variables as the determinants of CEO ownership. We use the natural logarithm of assets as the measure of firm size. We use the growth rate of sales over the previous year as the measure of growth opportunities. We use the ratio of the sum of re-

Table 1
Univariate statistics

Variable	Mean	Median
CEO ownership	0.0342	0.0103
Tobin's Q	1.9896	1.4867
Size	21.3331	21.1677
Cash flow	0.0475	0.0468
Sales growth	0.1104	0.0886
Plant, property and equipment	0.4883	0.2417
R&D and advertising	0.1108	0.0000
Earnings volatility	0.0294	0.0154
Sales volatility	0.1038	0.0661
Stock return	0.1814	0.1902
Stock return volatility	0.3862	0.3437

This table reports univariate statistics. The sample consists of 1058 firms with 6348 firm-year observations from 1995 to 2000. *CEO ownership* is defined as the sum of the proportion of shares outstanding held by a CEO plus the proportion of shares outstanding in options held by the CEO times the Black–Scholes hedge ratio (the delta). *Tobin's Q* is the market value of equity plus the book value of assets minus the book value of common equity, divided by the book value of assets. *Size* is the natural logarithm of the book value of assets. *Cash flow* is the ratio of income before extraordinary items to assets. *Sales growth* is the growth rate of sales over the previous year. *Plant, property and equipment* is the ratio of PPE to assets. *R&D and advertising* is the ratio of the sum of research and development expenses and advertising expenses divided by total expenses. *Earnings volatility* is the standard deviation of the ratio of income before extraordinary items to assets in the prior three years. *Sales volatility* is the standard deviation of the natural logarithm of sales in the prior three years. *Stock return* is one-year stock return. *Stock return volatility* is the annualized standard deviation of monthly return during the year.

search and development expenses and advertising expenses divided by total expenses as the measure of soft capital. We use the ratio of income before extraordinary items to assets as the measure of cash flow. We use the ratio of plant, property and equipment to assets as the measure of capital intensity. We use the standard deviation of the ratio of income before extraordinary items to assets in the prior three years, and the standard deviation of the natural logarithm of sales in the prior three years as the measures of volatility in the operating environment. We also include the square of size and the square of cash flow as control variables. Table 1 presents univariate statistics. We winsorize the data to reduce the impact of outliers.

3. Deviations from optimal CEO ownership

We describe the methodology used to obtain the measures of deviations from optimal CEO ownership in this section. To find a benchmark specification for the determinants of CEO ownership, we estimate the following regression:

$$\begin{aligned}\text{CEO ownership}_{it} = {} & a_i + c_1(\text{Size}_{it}) + c_2(\text{Size}_{it}^2) \\ & + c_3(\text{Cash flow}_{it}) + c_4(\text{Cash flow}_{it}^2) \\ & + c_5(\text{Sales growth}_{it}) \\ & + c_6(\text{Plant, property and equipment}_{it}) \\ & + c_7(\text{R\&D and advertising}_{it}) \\ & + c_8(\text{Earnings volatility}_{it}) \\ & + c_9(\text{Sales volatility}_{it}) + \varepsilon_{it}. \end{aligned} \tag{4}$$

Definition of deviations: We define Deviation as the absolute value of the residuals. We define Above-Optimal Dummy as a dummy variable that equals 1 for positive residuals and 0 otherwise.

These two measures will be used in the later analysis. The residuals in the firm fixed effect regression are used to construct the measures of deviations from optimal CEO ownership. The residuals are not explained by a firm's contracting environment, and thus correspond to the assumption of the transaction cost theory that managerial ownership can exogenously deviate from the optimal level. We use the absolute value of the residuals because the transaction cost theory predicts that both below-optimal and above-optimal deviations reduce firm value. The Above-Optimal Dummy is used in the situations where the direction of the deviations needs to be identified.

Since this essentially represents a two-step methodology, one may naturally question whether the benchmark specification in the first step is appropriate. We recognize that debates already exist in the literature. For example, while Himmelberg et al. (1999) propose the arguments in favor of using fixed effect regressions, Zhou (2001) raises certain drawbacks of this method based on the fact that ownership is stable over time. We do not attempt to resolve this debate here. Instead, we treat the first-step regression as an empirical specification, and focus on the second-step analysis of firm value.

We rely on a type of joint-test argument to validate the results. Suppose the first-step specification does not provide a proper description of the determinants of CEO ownership, it is more likely that the residuals are just noises so that they will not have a systematic relation with firm value as predicted by the transaction cost theory in the second-step analysis. However, suppose we do find a negative and significant relation between deviations on either side of optimal CEO ownership and firm value using the measures constructed with these residuals, this can in turn imply that the first-step specification gives a reasonable description of the determinants of CEO ownership.

This joint-test argument, however, is subject to the limitation of the omitted variable problem. Suppose there is an omitted variable in the first step that has a non-linear relation with firm value, it will be captured by residuals and reveal a spurious correlation between the residuals and firm value in the second-step analysis. We cannot exhaust the possibilities of omitted variables in any empirical specification. We therefore conduct the second-step analysis using both the level of and the change in firm value, because it is less likely for an omitted variable to have exactly the same relation with both Tobin's Q and short-term cumulative abnormal returns in the two events as predicted by the transaction cost theory.

4. Deviations and the level of firm value

We investigate the relation between deviations from optimal CEO ownership and the level of firm value in this section.

4.1. Methodology

Himmelberg et al. (1999) argue that firm value is affected by the same contracting parameters as the determinants of managerial ownership. We use the same control variables as the determinants of CEO ownership in the second-step regression. We expect $b_1 < 0$ in the following Eq. (5), implying a negative relation between deviations from optimal CEO ownership and Tobin's Q:

$$\begin{aligned}\text{Tobin's Q}_{it} = {} & a_i + b_1(\text{Deviation}_{it}) + c_1(\text{Size}_{it}) + c_2(\text{Size}_{it}^2) \\ & + c_3(\text{Cash flow}_{it}) + c_4(\text{Cash flow}_{it}^2) \\ & + c_5(\text{Sales growth}_{it}) \\ & + c_6(\text{Plant, property and equipment}_{it}) \\ & + c_7(\text{R\&D and advertising}_{it}) \\ & + c_8(\text{Earnings volatility}_{it}) \\ & + c_9(\text{Sales volatility}_{it}) + \eta_{it}. \end{aligned} \tag{5}$$

To test whether deviations on either side of optimal CEO ownership reduce Tobin's Q, we construct an interaction term, Deviation $*$ Above-optimal dummy. We expect $b_2 < 0$ and $b_2 + b_3 < 0$ in the following Eq. (6), indicating a negative impact of both above-optimal and below-optimal deviations on Tobin's Q:

$$\begin{aligned}\text{Tobin's Q}_{it} = {} & a_i + b_2(\text{Deviation}_{it}) + b_3((\text{Deviation} \\ & * \text{Above-optimal dummy})_{it}) + c_1(\text{Size}_{it}) \\ & + c_2(\text{Size}_{it}^2) + c_3(\text{Cash flow}_{it}) + c_4(\text{Cash flow}_{it}^2) \\ & + c_5(\text{Sales growth}_{it}) \\ & + c_6(\text{Plant, property and equipment}_{it}) \\ & + c_7(\text{R\&D and advertising}_{it}) \\ & + c_8(\text{Earnings volatility}_{it}) \\ & + c_9(\text{Sales volatility}_{it}) + \eta_{it}. \end{aligned} \tag{6}$$

4.2. Results

We first report the results using a firm fixed effect regression as the benchmark specification for the determinants of CEO ownership. We then examine the relation between deviations from optimal CEO ownership and Tobin's Q.

4.2.1. Benchmark specification

Table 2 presents the results on the determinants of CEO ownership. A first observation is that the adjusted R^2 is 90% in the firm fixed effect regression, implying that exogenous deviations

Table 2
Benchmark specification

	CEO ownership
Size	−0.052
	(0.01)
Size square	0.001
	(0.01)
Cash flow	0.011
	(0.07)
Cash flow square	−0.072
	(0.01)
Sales growth	0.004
	(0.02)
Plant, property and equipment	0.001
	(0.35)
R&D and advertising	−0.007
	(0.26)
Earnings volatility	−0.028
	(0.01)
Sales volatility	0.003
	(0.45)
Firm-specific intercepts	Yes
Adjusted R^2	0.90
F-test on equal intercepts (*p*-value)	0.01

This table reports the determinants of CEO ownership using a firm fixed effect regression. The sample consists of 1058 firms with 6348 firm-year observations from 1995 to 2000. The dependent variable is *CEO ownership*, defined as the sum of the proportion of shares outstanding held by a CEO plus the proportion of shares outstanding in options held by the CEO times the Black–Scholes hedge ratio (the delta). *Size* is the natural logarithm of the book value of assets. *Cash flow* is the ratio of income before extraordinary items to assets. *Sales growth* is the growth rate of sales over the previous year. *Plant, property and equipment* is the ratio of PPE to assets. *R&D and advertising* is the ratio of the sum of research and development expenses and advertising expenses divided by total expenses. *Earnings volatility* is the standard deviation of the ratio of income before extraordinary items to assets in the prior three years. *Sales volatility* is the standard deviation of the natural logarithm of sales in the prior three years. The *p*-value is noted in the brackets.

Table 3
Deviations and the level of firm value

	Tobin's Q	Tobin's Q
Deviation	−5.513	−5.718
	(0.01)	(0.01)
Deviation * Above-optimal dummy		0.343
		(0.68)
Size	−1.852	−1.851
	(0.01)	(0.01)
Size square	0.042	0.043
	(0.01)	(0.01)
Cash flow	4.338	4.340
	(0.01)	(0.01)
Cash flow square	16.692	16.695
	(0.01)	(0.01)
Sales growth	0.375	0.376
	(0.01)	(0.01)
Plant, property and equipment	0.035	0.035
	(0.46)	(0.45)
R&D and advertising	0.484	0.484
	(0.01)	(0.01)
Earnings volatility	0.347	0.345
	(0.29)	(0.30)
Sales volatility	−0.196	−0.195
	(0.07)	(0.07)
Firm-specific intercepts	Yes	Yes
F-test (*p*-value)		0.01
Adjusted R^2	0.92	0.92

This table reports the relation between deviations from optimal CEO ownership and the level of firm value. The sample consists of 1058 firms with 6348 firm-year observations from 1995 to 2000. The dependent variable is *Tobin's Q*, defined as the market value of equity plus the book value of assets minus the book value of common equity, divided by the book value of assets. *Deviation* is the absolute value of the residuals in the benchmark specification in Table 2. *Above-optimal dummy* equals 1 if actual CEO ownership is greater than optimal CEO ownership, and equals 0 otherwise. *Size* is the natural logarithm of the book value of assets. *Cash flow* is the ratio of income before extraordinary items to assets. *Sales growth* is the growth rate of sales over the previous year. *Plant, property and equipment* is the ratio of PPE to assets. *R&D and advertising* is the ratio of the sum of research and development expenses and advertising expenses divided by total expenses. *Earnings volatility* is the standard deviation of the ratio of income before extraordinary items to assets in the prior three years. *Sales volatility* is the standard deviation of the natural logarithm of sales in the prior three years. *F-test* refers to an F test on the null hypothesis that the sum of the coefficients of Deviation and Deviation * Above-optimal dummy is zero. The *p*-value is noted in the brackets.

from the optimal level explain about 10% of CEO ownership. This magnitude is consistent with the findings in the literature of managerial ownership. For example, Himmelberg et al. (1999) find that the adjusted R^2 can reach 88% using firm fixed effect regressions for the determinants of managerial ownership.[2] Zhou (2001) presents several fixed effect specifications with equity ownership as dependent variables, and shows that the adjusted R^2 can hit 94%.[3] We conduct an *F*-test on the null hypothesis of equal intercepts across firms. It rejects the null hypothesis at 1% level, indicating that intercepts in the firm fixed effect regression are indeed firm-specific.

4.2.2. Deviations and the level of firm value

Table 3 presents the results on deviations from optimal CEO ownership and the level of firm value. The dependent variable in the regressions is Tobin's Q. Deviations from optimal CEO ownership are defined as the absolute value of the residuals. In the first column, we find that the coefficient of Deviation is negative and significant. It implies that a deviation from optimal CEO ownership by 0.01 on average results in a decrease in Tobin's Q by 0.055.[4] The second column of Table 3 shows a regression with the interaction term. We find that the coefficient of Deviation is −5.718, and the sum of the coefficient of Deviation and the coefficient of the interaction term, Deviation * Above-optimal dummy, is −5.375 (=−5.718 + 0.343). An *F*-test reveals that the sum of these two coefficients is significant at 1% level. These results support the hypothesis that deviations on either side of optimal CEO ownership reduce firm value.

The results in the second column indicate that the difference in the negative impacts on firm value is not statistically significant between above-optimal and below-optimal deviations. The coefficient of the interaction term, Deviation * Above-optimal dummy, is 0.343 with a *p*-value of 0.68. This represents a similar pattern of the relation between deviations and firm value on both sides of the optimal level, which is consistent with an implied prediction of the transaction cost theory. Namely, if firms' re-optimization eliminates the overall relation between managerial ownership and firm value, we expect a similar effect on firm value between above-optimal and below-optimal deviations. The effects will offset each other if we pool the observations on both sides of the optimal level, resulting in an overall insignificant relation between ownership and firm value as reported by previous papers in the literature (e.g., Demsetz and Lehn, 1985; Himmelberg et al., 1999).

4.3. Size-adjusted deviations

We conduct a robustness check using size-adjusted deviations that are defined as deviations standardized by firm size.

[2] See Himmelberg et al. (1999, p. 368).
[3] See Zhou (2001, p. 569).
[4] We believe that this magnitude is reasonable compared with the findings in Core and Larcker (2002). They find that a target ownership plan is associated with an average increase in the logarithm of the ratio (CEO Stock Value/Salary) by 14.1% within 2 years after the adoption of the plan. This is accompanied by an excess stock return of 5.3% during the same period. See Core and Larcker (2002, pp. 331, 334).

This is due to the consideration that firm size may affect the magnitude of deviations. For example, since more dollars are required for a CEO to purchase a certain fraction of ownership of a large firm than of a small firm, we may find more deviations from optimal ownership in large firms, because of a capital constraint the CEO cannot purchase enough shares to reach the optimal level. As a result, the magnitude of deviations will capture the size effect. Size-adjusted deviations can provide a treatment for this. We find similar results that size-adjusted deviations on either side of optimal CEO ownership significantly reduce firm value.

5. Deviations and the change in firm value

We investigate the relation between deviations from optimal CEO ownership and the change in firm value in this section. We use the same variable "Above-optimal dummy" in the previous analysis as the measure of deviations.

5.1. Data and methodology

We examine two events that change CEO ownership: sales and purchases of shares by CEOs. We obtain the data from the Thomson Financial Insider database covering the period 1996–2000. In this sample period, insiders were required to report the trading in their firms' shares to the Securities and Exchange Committee (SEC) by the 10th of the month following the trade. We focus on a subset of the reported trades. First, we include the trading of at least 10,000 shares. Second, we only consider open market sales and purchases. Third, we only include the trading reported to the SEC by the 10th of the month following the trade, thus excluding the trading with postponed reporting.

Following McConnell et al. (2005), we set the date on which the insider trading is reported to the SEC (SEC receipt date) as the event date, because the information becomes available to investors after insiders file their transaction to the SEC (e.g., Lakonishok and Lee, 2001). We use the cumulative abnormal return over days (−10,+10) around the event date as the measure of the change in firm value. The cumulative abnormal return is calculated using the market model with the CRSP equally weighted index as the market return. To estimate the market model, we use a firm's daily return and the return on the CRSP equally weighted index over days −300 to −20, where day 0 is the event date.

Since sales of shares can be associated with option exercises, this may affect the analysis due to the intervals between option exercises and sales. Insiders were allowed to immediately sell shares after option exercises during the sample period 1996–2000. Ofek and Yermack (2000) find that managers sell nearly all the shares after option exercises. We obtain the data on option exercises from Thomson Financial. Since we use the SEC receipt date as the event date, we only include the events in the sample if both option exercises and sales of shares have taken place before the SEC receipt date. This is to ensure that sales of shares have already occurred when investors receive the information.[5] After these screening procedures, we obtain a sample that contains 1266 sales events and 303 purchases events.

We expect that sales of shares by CEOs will be associated with a higher abnormal return for an above-optimal deviation than a below-optimal deviation. Since sales reduce CEO ownership, they move CEO ownership towards (away from) the optimal level if there has previously been an above-optimal (below-optimal) deviation. Similarly, we expect that purchases of shares by CEOs will be associated with a lower abnormal return for an above-optimal deviation than a below-optimal deviation.

We use the following regressions to examine the events. The dependent variable is cumulative abnormal return. Among the independent variables, we include the Above-optimal dummy to investigate the impact of deviations from optimal CEO ownership on the change in firm value. We include the changes of contracting parameters as control variables in the regressions, because both the change in firm value and the change in CEO ownership are driven by the changes of contracting parameters as suggested by Himmelberg et al. (1999). We include a prior six-month run-up in the regression, controlling for the potential overvaluation or undervaluation (e.g., Faccio and Masulis, 2005). We expect $b_4 > 0$ in the following Eq. (7), and $b_5 < 0$ in the following Eq. (8):

Sales of shares by CEOs:

$$\begin{aligned}\text{Cumulative abnormal return}_i &= a + b_4((\text{Above-optimal dummy } t-1)_i)\\ &+ c_1(\text{Size change}_i)\\ &+ c_2(\text{Cash flow change}_i)\\ &+ c_3(\text{Sales growth change}_i)\\ &+ c_4(\text{Property, plant and equipment change}_i)\\ &+ c_5(\text{R\&D change}_i)\\ &+ c_6(\text{Earning volatility change}_i)\\ &+ c_7(\text{Sales volatility change}_i)\\ &+ c_8(\text{Run-up}_i) + \eta_i. \end{aligned} \tag{7}$$

Purchases of shares by CEOs:

$$\begin{aligned}\text{Cumulative abnormal return}_i &= a + b_5((\text{Above-optimal dummy } t-1)_i)\\ &+ c_1(\text{Size change}_i)\\ &+ c_2(\text{Cash flow change}_i)\\ &+ c_3(\text{Sales growth change}_i)\\ &+ c_4(\text{Property, plant and equipment change}_i)\\ &+ c_5(\text{R\&D change}_i)\\ &+ c_6(\text{Earning volatility change}_i)\\ &+ c_7(\text{Sales volatility change}_i)\\ &+ c_8(\text{Run-up}_i) + \eta_i. \end{aligned} \tag{8}$$

5.2. Results

We show the univariate analyses in Table 4. We divide the sample into two groups depending on whether CEO ownership is above or below the optimal level in the year $t-1$, and report the results in Panel A. The first row of Panel A shows that the mean of abnormal returns associated with sales is −0.016 (p-value = 0.01) for the sub-sample of below-optimal deviations, and that the mean is −0.007 (p-value = 0.16) for the sub-sample of above-optimal deviations. This is consistent with the following interpretation. If there is a relation between CEO ownership and firm value through signaling (e.g., Leland and Pyle, 1977), then sales of shares by CEOs will be associated with a negative abnormal return. However, sales also move CEO ownership towards the optimal level for the sub-sample of above-optimal deviations. Since these two effects offset each other, we do not find a significant abnormal return for this sub-sample.

[5] Since insider trading can be reported to the SEC by the 10th of the month following the trade, it means that the sample includes some events with short intervals between option exercises and insider sales of shares, as long as they both take place before the SEC receipt date.

Table 4
Univariate analyses on abnormal returns

	Mean of cumulative abnormal return	
	Sub-sample: Below-optimal deviations in year $t-1$	Sub-sample: Above-optimal deviations in year $t-1$
Panel A: Sub-samples		
Sales of shares by CEOs	−0.016	−0.007
	(0.01)	(0.16)
Purchases of shares by CEOs	0.055	0.036
	(0.01)	(0.01)
	Sub-sample: Below-optimal deviations in year $t-1$ *Bottom quartile*	Sub-sample: Above-optimal deviations in year $t-1$ *Top quartile*
Panel B: Sub-samples with a larger degree of deviations		
Sales of shares by CEOs	−0.020	−0.004
	(0.01)	(0.54)
Purchases of shares by CEOs	0.069	0.021
	(0.01)	(0.20)

This table reports univariate analyses on abnormal returns. We study two events that change the proportion of CEO ownership: sales of shares by CEOs (1266 events) and purchases of shares by CEOs (303 events). We divide the sample into two groups depending on whether CEO ownership is above or below the optimal level in the year $t-1$, and report the results in Panel A. *Cumulative abnormal return* is calculated as the cumulative abnormal return over days (−10,+10) around the event date using the market model with the CRSP equally weighted index as the market return. We examine the sub-samples with a larger degree of deviations, and report the results in Panel B (see text for more details). The *p*-value of the mean test is noted in the brackets.

The second row of Panel A shows that the mean of abnormal returns associated with purchases is 0.055 (*p*-value = 0.01) for the sub-sample of below-optimal deviations, and that the mean is 0.036 (*p*-value = 0.01) for the sub-sample of above-optimal deviations. The results can be interpreted as showing a stronger signaling effect in the situation of purchases because both groups have positive abnormal returns. Nevertheless, we still find a lower abnormal return for the sub-sample of above-optimal deviations. This is consistent with the interpretation that the positive effect of purchases is to some extent offset by the fact that purchases move the ownership away from the optimal level for this sub-sample.[6]

We repeat the univariate analysis for the sub-samples with a larger degree of deviations, and report the results in Panel B. We examine the distribution of the residual CEO ownership standardized by firm size[7] in year $t-1$, and construct the sub-samples with the observations in the bottom quartile (implying a large degree of below-optimal deviations) or top quartile (implying a large degree of above-optimal deviations). We find similar results in terms of sales of shares in this panel. Moreover, Panel B shows that the mean of abnormal returns associated with purchases is 0.021 (*p*-value = 0.20) for the sub-sample with a larger degree of above-optimal deviations. This is consistent with the interpretation that purchases move the ownership further away from the optimal level for this sub-sample, which offsets the positive effect of signaling and results in an insignificant abnormal return.

We report the regressions in Table 5. In the first column, we find that the coefficient of Above-optimal dummy$_{t-1}$ is 0.012 in the regression of sales of shares by CEOs, indicating that sales are associated with a higher abnormal return in the case of above-optimal deviations because they move CEO ownership towards the optimal level. In the second column, we find that the coefficient of Above-optimal dummy$_{t-1}$ is −0.036 in the regression of purchases of shares by CEOs, indicating that purchases are associated with a lower abnormal return in the case of above-optimal deviations because they move CEO ownership away from the optimal level. The coefficients of Above-optimal dummy$_{t-1}$ in both columns are statistically significant. The findings support the predictions of the transaction cost theory.

Table 5
Deviations and the change in firm value

	Cumulative abnormal return	
	Sales of shares	Purchases of shares
Intercept	−0.024	0.055
	(0.01)	(0.01)
Above-optimal dummy $t-1$	0.012	-0.036
	(0.07)	(0.03)
Size change	0.022	−0.045
	(0.10)	(0.26)
Cash flow change	0.047	0.246
	(0.30)	(0.03)
Sales growth change	0.031	0.032
	(0.04)	(0.38)
Property, plant and equipment change	0.030	−0.026
	(0.19)	(0.56)
R&D and advertising change	−0.014	−0.251
	(0.79)	(0.10)
Earnings volatility change	0.270	0.222
	(0.02)	(0.42)
Sales volatility change	−0.017	−0.033
	(0.62)	(0.71)
Run-up	0.006	−0.084
	(0.46)	(0.01)
Adjusted R^2	0.02	0.06

This table reports the relation between deviations and the change in firm value. We study two events that change the proportion of CEO ownership: sales of shares by CEOs (1266 events) and purchases of shares by CEOs (303 events). The dependent variable is *Cumulative abnormal return*, defined as the cumulative abnormal return over days (−10,+10) around the event date using the market model with the CRSP equally weighted index as the market return (see text for more details). *Above-optimal dummy $t-1$* equals 1 if actual CEO ownership is greater than optimal CEO ownership in the year $t-1$, and equals 0 otherwise. *Size* is the natural logarithm of the book value of assets. *Cash flow* is the ratio of income before extraordinary items to assets. *Sales growth* is the growth rate of sales over the previous year. *Plant, property and equipment* is the ratio of PPE to assets. *R&D and advertising* is the ratio of the sum of research and development expenses and advertising expenses divided by total expenses. *Earnings volatility* is the standard deviation of the ratio of income before extraordinary items to assets in the prior three years. *Sales volatility* is the standard deviation of the natural logarithm of sales in the prior three years. *Run-up* is the sum of a firm's monthly return in the prior six months. The *p*-value is noted in the brackets.

We conduct a robustness check by including more control variables in the regressions. These variables are the lag of firm characteristics that are used by previous papers in the literature (e.g., the lag of size, the lag of cash flow). We find similar results as in Table 5.

5.3. Heckman two-stage estimation

Firms can self-select to undertake these events that change CEO ownership. We use the Heckman (1979) two-stage estimation as a treatment for this self-selection problem. In the first stage, we use probit regressions to model the likelihoods of these events. We include the Above-optimal dummy at year $t-1$ in each regression. This allows us to study whether a deviation from optimal CEO ownership affects the likelihoods of these events. We include other control variables in the probit regressions based on the literature of the determinants of insider trading (e.g., Seyhun, 1986; Lakonishok and Lee, 2001). We follow the standard of the Heckman methodology, and obtain the inverse Mills ratios from the probit estimates. The calculation of the inverse Mills ratio is illustrated in Appendix A. In the second stage, we estimate the regressions with the inverse

[6] The positive abnormal returns in the sub-sample of above-optimal deviations do not reject the hypothesis of the transaction cost theory. The univariate abnormal returns reflect a combination of the various effects at work in an event.

[7] We have discussed size-adjusted deviations in Section 4. Using size-adjusted deviations is due to the consideration that firm size may affect the magnitude of deviations.

Table 6
Heckman two-stage estimation — first stage: probit regressions

	Sales of shares	Purchases of shares
Intercept	−2.883	−2.731
	(0.01)	(0.01)
Above-optimal dummy $t-1$	0.154	-0.120
	(0.01)	(0.21)
Size $t-1$	0.062	0.039
	(0.01)	(0.04)
Sales growth $t-1$	0.632	0.238
	(0.01)	(0.12)
R&D and advertising $t-1$	1.110	0.137
	(0.01)	(0.47)
Stock return $t-1$	0.641	−0.598
	(0.01)	(0.01)
Stock return volatility $t-1$	0.280	0.802
	(0.03)	(0.01)
Pseudo R^2	0.07	0.02

This table reports probit regressions. The sample consists of 1058 firms with 6348 firm-year observations from 1995 to 2000. We study two events that change the proportion of CEO ownership: sales of shares by CEOs (1266 events) and purchases of shares by CEOs (303 events). The dependent variable is 1 if the event occurs, and is 0 otherwise. *Above-optimal dummy t − 1* equals 1 if actual CEO ownership is greater than optimal CEO ownership in the year $t-1$, and equals 0 otherwise. *Size* is the natural logarithm of the book value of assets. *Sales growth* is the growth rate of sales over the previous year. *R&D and advertising* is the ratio of the sum of research and development expenses and advertising expenses divided by total expenses. *Stock return* is one-year stock return. *Stock return volatility* is the annualized standard deviation of monthly return during the year. The *p*-value is noted in the brackets.

Table 7
Heckman two-stage estimation — second stage: deviations and the change in firm value

	Cumulative abnormal return	
	Sales of shares	Purchases of shares
Intercept	−0.063	0.119
	(0.01)	(0.12)
Above-optimal dummy $t-1$	0.015	−0.036
	(0.02)	(0.03)
Size change	0.032	−0.029
	(0.02)	(0.49)
Cash flow change	0.059	0.254
	(0.20)	(0.03)
Sales growth change	0.020	0.033
	(0.20)	(0.36)
Property, plant and equipment change	0.026	−0.026
	(0.26)	(0.57)
R&D and advertising change	−0.020	−0.256
	(0.70)	(0.09)
Earnings volatility change	0.244	0.191
	(0.03)	(0.49)
Sales volatility change	−0.015	−0.033
	(0.68)	(0.71)
Run-up	0.012	−0.078
	(0.14)	(0.01)
Inverse Mills ratio	0.024	−0.032
	(0.03)	(0.39)
Adjusted R^2	0.02	0.06

This table reports the second-stage regressions. We study two events that change the proportion of CEO ownership: sales of shares by CEOs (1266 events) and purchases of shares by CEOs (303 events). The dependent variable is *Cumulative abnormal return*, defined as the cumulative abnormal return over days (−10,+10) around the event date using the market model with the CRSP equally weighted index as the market return (See text for more details). *Above-optimal dummy t − 1* equals 1 if actual CEO ownership is greater than optimal CEO ownership in the year $t-1$, and equals 0 otherwise. *Size* is the natural logarithm of the book value of assets. *Cash flow* is the ratio of income before extraordinary items to assets. *Sales growth* is the growth rate of sales over the previous year. *Plant, property and equipment* is the ratio of PPE to assets. *R&D and advertising* is the ratio of the sum of research and development expenses and advertising expenses divided by total expenses. *Earnings volatility* is the standard deviation of the ratio of income before extraordinary items to assets in the prior three years. *Sales volatility* is the standard deviation of the natural logarithm of sales in the prior three years. *Run-up* is the sum of a firm's monthly return in the prior six months. *Inverse Mills ratio* is obtained from the probit estimates in Table 6 (see Appendix A for more details on the calculation). The *p*-value is noted in the brackets.

Mills ratios as additional control variables. This provides a treatment for the self-selection problem.

Table 6 shows the probit regressions. In the first column, we find that the coefficient of Above-optimal dummy$_{t-1}$ is 0.154 in the regression of sales, implying that sales are more likely to take place if there has been an above-optimal deviation. We do not find a significant coefficient of Above-optimal dummy$_{t-1}$ in the regression of purchases, though the sign is correct as predicted by the transaction cost theory.

These findings are interesting from the perspective of the transaction cost theory. It implies that sales of shares by CEOs demonstrate a pattern consistent with a firm's periodical re-optimization of sub-optimal CEO ownership. While the re-optimization may not be a primary motivation for sales of shares, at least it is one of the significant factors that affect the likelihood of the occurrence of this event. We can also draw some implications from the insignificant coefficient of Above-optimal dummy$_{t-1}$ in the regression of purchases. It is easier to persuade a CEO to sell shares than purchase shares, corresponding with a significant (insignificant) coefficient of Above-optimal dummy$_{t-1}$ in the probit regression of sales (purchases). These findings are consistent with the rationale of the transaction cost theory.

We report the second-stage regressions in Table 7. The inverse Mills ratios are included in the regression. We find similar results in this table with a higher statistical significance. In the first column, we find that the coefficient of Above-optimal dummy$_{t-1}$ is 0.015 (p-value = 0.02) in the regression of sales by CEOs. In the second column, we find that the coefficient of Above-optimal dummy$_{t-1}$ is −0.036 (p-value = 0.03) in the regression of purchases by CEOs. The results indicate that sales (purchases) are associated with a higher (lower) abnormal return in the case of above-optimal deviations.

5.4. Deviations before and after the events

We have assumed that sales of shares by CEOs will move the ownership towards the optimal level for the situation of above-optimal deviations. This assumption, however, is subject to a limitation. Suppose a CEO sells a large number of shares, it is possible that the ownership will move from an above-optimal deviation to a below-optimal deviation. Similar concerns can be applied to purchases of shares.

To check whether this issue is important for our sample, we first investigate the deviations before and after the events by examining the residuals at year $t-1$ and year t. We find that the mean of the residuals[8] is 0.0016 (p-value = 0.01) before sales of shares, and that the mean is −0.0004 (p-value = 0.38) after the sales. We find that the mean of the residuals is −0.0017 (p-value = 0.14) before purchases of shares, and that the mean is 0.0005 (p-value = 0.61) after the purchases. The results support the interpretation that most of the events in our sample are not associated with a significant switch between below-optimal deviations and above-optimal deviations. Next we repeat the analysis by excluding the observations (215 out of 1266 events) with a switch from an above-optimal deviation to a below-optimal deviation after sales of shares, and the observations (67 out of 303 events) with a switch from a below-optimal deviation to an above-optimal deviation after purchases of shares. We find consistent results.

[8] We examine the signed residuals instead of the absolute value of the residuals because we need know whether the ownership is above or below the optimal level.

5.5. Robustness check on option exercises

Market reactions can be different depending on whether sales of shares are associated with option exercises. We conduct a robustness check by including an "Option exercise dummy" in the regression. The variable equals 1 if a sale is associated with option exercises, and equals 0 otherwise. We find similar results in this robustness check.

6. Conclusion

This paper tests the transaction cost theory of managerial ownership and firm value by studying the relation between deviations on either side of optimal CEO ownership and firm value. This enables us to examine the predictions of the transaction cost theory on both above-optimal and below-optimal deviations. We find that deviations on either side of optimal CEO ownership reduce the level of firm value measured by Tobin's Q. We examine the change in firm value by investigating two events that change CEO ownership. We find that a change in CEO ownership is associated with a higher (lower) abnormal return if it moves the ownership towards (away from) the optimal level.

These results support the interpretation that deviations on either side of optimal CEO ownership reduce firm value. We conclude that they are consistent with the transaction cost theory of managerial ownership and firm value, and that they reconcile the contrasting predictions and findings of Morck et al. (1988) and Demsetz and Lehn (1985).

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Appendix A. Definition of the variables

CEO ownership	CEO ownership is defined as the sum of the proportion of shares outstanding held by a CEO plus the proportion of shares outstanding in options held by the CEO times the Black–Scholes hedge ratio (the delta). See Appendix B for more details on the calculation
Tobin's Q	Tobin's Q is defined as the market value of equity (Compustat item #25 multiplied by #199) plus the book value of assets (#6) minus the book value of common equity (#60), divided by the book value of assets (#6)
Size	Size is defined as the natural logarithm of the book value of assets (#6)
Cash flow	Cash flow is defined as the ratio of income before extraordinary items (#18) to assets (#6)
Sales growth	Sales growth is defined as the growth rate of sales (#12) over the previous year
Plant, property and equipment	Plant, property and equipment is defined as the ratio of plant, property and equipment (#8) to assets (#6)
R&D and advertising	R&D and advertising is defined as the ratio of the sum of research and development expenses (#46) and advertising expenses (#45) divided by total expenses (#189). The missing value is set to zero
Earnings volatility	Earnings volatility is defined as the standard deviation of the ratio of income before extraordinary items (#18) to assets (#6) in the prior three years
Sales volatility	Sales volatility is defined as the standard deviation of the natural logarithm of sales (#12) in the prior three years
Stock return	Stock return is defined as one-year stock return
Stock return volatility	Stock return volatility is defined as the annualized standard deviation of monthly return during the year
Cumulative abnormal return	Cumulative abnormal return is defined as the cumulative abnormal return over days $(-10,+10)$ around the event date. The event date of sales/purchases of shares is the date that sales/purchases are reported to the SEC. To estimate the market model, we use a firm's daily return and the return on the CRSP equally weighted index over days -300 to -20, where day 0 is the event date
Run-up	Run-up is defined as the sum of a firm's monthly returns in the prior six months
Inverse Mills ratio	We assume that the likelihood of an event is determined by: $D_{it}* = \gamma Z_{it} + u_{it}$ $D_{it} = 1, \quad \text{if } D_{it}^* > 0$ $D_{it} = 0 \quad \text{if } D_{it}^* < 0$ where D_{it}^* is an unobservable latent variable. D_{it} is a dummy variable (1 for the occurrence of the event, and 0 otherwise). Z_{it} is a set of variables that affect the likelihood. u_{it} is an error term We first estimate the above equation using a probit model to get the estimates of γ denoted by γ_e. Inverse Mills ratio is calculated as follows: $\text{Inverse Mills ratio}_{it} = \frac{\phi(\gamma_e Z_{it})}{\Phi(\gamma_e Z_{it})}$ where ϕ is the density function of the standard normal distribution. Φ is the cumulative distribution function of the standard normal distribution

Appendix B. The calculation of CEO ownership

We use the methodology in Core and Guay (1999, 2002) to calculate the measure of CEO ownership. The incentive from the stocks held by a CEO is calculated as the stock holdings divided by the number of shares outstanding.[9]

[9] We use the diluted shares outstanding as the denominator. We use the methodology in Cuny et al. (forthcoming) to obtain the data. We use Compustat item 171 (Common shares used to calculate diluted EPS), when Compustat item 171 is missing, we use Compustat item 54 (Common shares used to calculate basic EPS) and when that is also missing, we use Compustat item 25 (Common shares outstanding).

CEO option holdings are divided into newly granted options and previously granted options. For newly granted options, all six elements are available for the calculation: exercise price of the option, time to maturity, price of the underlying stock, expected dividend yield, expected stock return volatility, and risk-free interest rate. Exercise price of the option, time to maturity, and price of the underlying stock are directly available in Execucomp. We use the dividend yield during a fiscal year in Execucomp as the proxy for the expected dividend yield. We use the annualized stock return volatility as the proxy for the expected stock return volatility, calculated as the standard deviation of monthly stock returns during a year multiplied by $\sqrt{12}$. We get the 10-year treasury constant maturity rate at a fiscal-year end as the measure of risk-free interest rate from the website of the Federal Reserve Bank.

For previously granted options, two elements are unavailable in the current-year proxy statement: exercise price and time to maturity. We compute the average exercise price of exercisable and unexercisable options using the current realizable value in Execucomp. We set the time to maturity of the unexercisable options equal to one year less than the time to maturity of the grants in the most recent year, and set the time to maturity of the exercisable option equal to three years less than the time to maturity of the unexercisable options.

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