Managerial ownership and firm performance: A re-examination using productivity measurement

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Abstract

The role of productivity in firm performance is of fundamental importance to the US economy. Consistent with the corporate finance approach, this paper uses the ownership stake of a firm's managers as an argument in estimating the firm's production function. Accordingly, this paper brings together the corporate finance and productivity literature. Using a large sample of randomly selected manufacturing firms that does not suffer from any survivorship or large firm size biases, we find that managerial ownership changes are positively related to changes in productivity. We also find a higher sensitivity of changes in managerial ownership to changes in productivity for firms who experience greater than the median change in managerial ownership. These results are robust to including lagged estimates of production inputs, year dummies and separate dummies for each firm to control for unobservable firm characteristics. In addition, we find that the stock market rewards firms with increases in firm value when these firms increase their level of productivity. © 1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

During the past several years, a great deal of attention regarding the performance of the US economy has focused on productivity. This is not surprising given that many papers beginning with Solow (1957) have shown that approximately 90% of the increase in real per capita output (the standard of living) is attributable to efficiency growth. The importance of productivity to firm performance was featured in a cover story by Business Week (October 9, 1995), which states ''It's a catch phrase for our era, the Age of Productivity. The sense of urgency is all around … The US has also regained its primacy as the world's leading stock market … Underlying these gains is a powerful upsurge in productivity (pp. 134–135).''

While many papers have estimated production functions to determine productivity, most of them have omitted ''managerial variables'' as arguments in estimating production functions. [1] The exclusion of the management variable was originally addressed by Mundlak (1961) in proposing the firm-specific, fixed-effects model, where each firm gets a separate intercept. While his approach treats managerial quality and incentives as an unobservable constant for each firm, this paper uses managerial ownership of the firm's shares as a determinant of firm output (conditional on capital and labor) in the estimation of a firm's production function. This approach of using managerial compensation in evaluating firm performance has had a long history in the corporate finance literature. Accordingly, this paper brings together the corporate finance and productivity literature.

Since Berle and Means (1932), the manager–shareholder conflict has been studied extensively in the corporate finance literature. When principals such as shareholders do not have the necessary information or skills to manage the firm they often use agents or managers who hold little equity in the firm. Such an arrangement leads some agents to shirk or undertake suboptimal investment projects to maximize their own benefits, rather than maximizing the principal's wealth. Jensen and Meckling (1976) suggest that managers deviate from shareholder wealth-maximization by consuming perquisites when they do not have an ownership stake in the firm. Accordingly, more managerial ownership aligns managerial interests with shareholder interests. Leland and Pyle (1977) argue that managers use ownership stakes to signal to markets that they have projects of a high quality. Under these theories, more managerial ownership results in higher market value of the firm. Stulz (1988) proposes a different relationship. He models the takeover process as a game between managers and an outside bidder vying for the voting rights of a number of small, competitive and passive shareholders. Increases in managerial ownership forces the outside bidder to pay higher premiums to gain control of the firm. But when the managerial ownership stake is so

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[1] See Section 2 for more details on productivity and managerial ownership.

large that a takeover is not profitable to the bidder, it results in a low ex ante market value. Accordingly, increases in managerial ownership increase the premium that the bidder must offer, but decrease the probability that the bidder makes a bid. These two opposing forces imply that the firm's market value first increases and then decreases with each increase in the managerial ownership stake.

In an important empirical paper, Mørck et al. (1988) estimate a piecewise linear relationship between board ownership and average Tobin's Q (where Q is the sum of market value of equity, debt and preferred stock divided by the replacement value of assets). They find that Tobin's Q increases and then decreases with increases in managerial ownership, and suggest that the firm's market value is adversely affected between 5% and 25% managerial ownership levels. In this ownership range, managers are entrenched and can indulge in non-value-maximizing activities without being disciplined by their shareholders. At managerial ownership levels greater than 25%, the relationship between board ownership and Q once again turns positive.

McConnell and Servaes (1990), using a larger data set, find a quadratic relationship between managerial ownership and average Tobin's Q. Further, they find the relationship to turn slightly negative when managerial ownership reaches approximately 40% to 50%. Hermalin and Weisbach (1991) find average Q to increase until ownership reaches 1%, turns negative in the ownership range of 1% to 5%, turns positive again in the ownership range of 5% to 20%, and then turns negative for ownership levels greater than 20%. Hubbard and Palia (1995) examine mergers, and find that the bidder's excess returns increase until ownership levels of 5% and turn negative thereafter. Denis et al. (1994) find managers get entrenched at ownership levels of 1% or greater, since these managers experience lower turnover. We observe from the above corporate finance papers that the relationship between firm value and insider ownership is nonlinear, with the caveat that differences exist as to when the relationship becomes positive or negative.

This paper extends the previous literature in the following ways. First, it brings together the productivity and corporate finance literature by including the percentage of shares owned by managers (in their own firm) when estimating the firm's production function. Second, the previous literature used cross-sectional data only. In this paper, we use panel data to control for any unobservable firm heterogeneity. In criticizing the literature that examines the pay–performance relationship of chief executive officers (CEOs), Murphy (1985) motivates the optimal use of panel data in the following manner. ''Second, most previous results are based on cross-sectional analysis... Economic theories of efficient compensation suggest that, in addition to current performance, contracts will depend on other factors... Absent a theory indicating the relevant variables, and data on these variables, these cross-sectional models are inherently subject to a serious omitted variables problem (p. 12).'' Similar to this paper, Jensen and Murphy (1990) examine the CEO's pay–performance sensitivity obtained from the fixed-effects model only. Third, in

order to ensure that our results are not affected by endogenous regressors we use lagged managerial ownership as an independent variable. Fourth, we examine whether firms that have greater than the median increase in share ownership, experience greater increases in productivity. Fifth, we examine whether management ownership leads or lags productivity, given that Hall and Liebman (1998) have found that large changes in share ownership are correlated with increases in firm performance. Sixth, we construct a sample that does not suffer from any large firm or survivorship biases (see Section 3 of this paper for more details). Finally, we determine the relationship between productivity and Tobin's Q.

While the previous literature has used Tobin's Q as a proxy for firm performance, many authors such as Lang et al. (1996) have used it to proxy for the future investment opportunity set (i.e., the growth prospects facing the firm). We focus on a more primitive variable that captures the efficiency of the firm, namely, productivity. We do not suggest that one measure is necessarily better than the other, but we examine if they are correlated: in the sense that does the stock market reward higher (or lower) productivity firms with higher (or lower) Q values?

We begin by using total factor productivity (TFP) as our measure of company productivity. TFP has been used extensively by a number of authors such as Kim and Maximovic (1990), Lichtenberg and Siegel (1990), Caves and Barton (1991), Lichtenberg (1992), Lichtenberg and Pushner (1994) and Maximovic and Phillips (1995). We find that managerial ownership changes are positively related to changes in productivity. We also find a higher sensitivity of changes in managerial ownership to changes in productivity for firms who experience greater than the median change in managerial ownership. These results are robust to including lagged estimates of production inputs, year dummies and separate dummies for each firm to control for unobservable firm characteristics. In addition, we find that the stock market rewards firms with increases in firm value when these firms increase their level of productivity.

The paper is organized as follows. In Section 2, we develop the concept of firm productivity and present the corporate finance literature on the relationship between managerial ownership and the market value of a firm. Section 3 describes the data. In Section 4, we present our empirical tests and results. Section 5 concludes.

2. Firm productivity, market value and managerial ownership

2.1. The concept of firm productivity

Microeconomic theory postulates that the firm employs a bundle of resources or inputs, such as labor and capital, to produce output. For simplicity, we assume that

the firm produces a single product. The general definition of productivity is the ratio of (real) output to (real) input:

$$\gamma = Y/\text{input} \tag{1}$$

where γ denotes productivity and Y denotes output. The definition specifies real rather than nominal output and input because we seek to eliminate the influence of price changes when making productivity comparisons.

Because the firm employs more than one input, there are several ways of defining productivity, corresponding to different definitions of the denominator of Eq. (1). It is possible to define partial productivity measures, based on only a subset of the inputs employed by the firm. In fact, the best-known measure of productivity — labor productivity, output per unit of labor input — is a partial productivity measure. Labor productivity is important because it is closely related to, indeed almost synonymous with, per capita income (the ''standard of living''). We are concerned, however, with measuring producer efficiency, and labor productivity is an imperfect measure of efficiency, because it fails to account for the output contributions of other, nonlabor inputs.

A good index of efficiency must account for, and give proper weight to, the services of all of the inputs employed by the firm. TFP is such an index; it is defined as output per unit of total input, where total input is an index (weighted sum) of the individual inputs:

$$\gamma_T = Y/f(L,K) \tag{2}$$

where γ_T denotes TFP, $f(\cdot)$ denotes total input, L denotes labor input, and K denotes capital input. Precise definitions of L and K are provided below; for the moment, we define L as total hours worked and K as the real net stock of plant and equipment.

We can rearrange Eq. (2) to look like a production function, in which output is the dependent variable:

$$Y = \gamma_T * f(L,K). \tag{3}$$

Eq. (3) reveals that output produced is determined by the quantities of inputs employed and the efficiency of the producer. Choosing a functional form for $f(\cdot)$ is equivalent to specifying the form of the production function. We assume that $f(\cdot)$ is a Cobb–Douglas function, or geometrically weighted sum, of its arguments:

$$f(L,K) = L^\alpha K^\beta. \tag{4}$$

Hence, the production function is

$$Y = \gamma_T * L^\alpha K^\beta. \tag{5}$$

Taking logarithms, we obtain

$$\ln Y = \ln \gamma_T + \alpha \ln L + \beta \ln K. \tag{6}$$

Eq. (6) may be viewed as a local, first-order logarithmic approximation of any arbitrary production function. Although more complex (second-order) functional forms have been used in some applications, Maddala (1979, p. 309) has shown that, at least within ''a limited class of functions ... (viz. Cobb–Douglas, generalized Leontief, homogeneous translog, and homogeneous quadratic) differences in the functional form produce negligible differences in measures of multi-factor productivity.''

Our objective is to determine the effect of managerial ownership on the productivity of manufacturing firms. Given a set of data $\{Y_i, L_i, K_i\}$, $i = 1, \ldots, N$, for a set of firms in an industry, each firm's TFP γ_{Ti} (relative to mean productivity in the industry) can under certain assumptions be inferred using Eq. (6). Suppose that the technical parameters α and β are invariant across firms, and that TFP varies across firms but is unobservable. Under these assumptions we can rewrite Eq. (6) as follows:

$$\ln Y_i = \alpha \ln L_i + \beta \ln K_i + u_i \tag{7}$$

where $u_i \equiv \ln \gamma_{Ti}$. Hence, we hypothesize that productivity u_i is related to managerial ownership by some functional form $g(\cdot)$ which we attempt to determine. Accordingly, we can rewrite Eq. (7) as

$$\ln Y_i = \alpha \ln L_i + \beta \ln K_i + g(\cdot) + e_i \tag{8}$$

where e_i is an i.i.d. error term. In the corporate finance literature, firm performance has been proxied by Tobin's Q, and $g(\cdot)$ is a quadratic specification or a piecewise linear specification. In this paper, we proxy firm performance by a more fundamental variable, namely, the efficiency or the productivity of the firm. Hence, we examine whether the relationship between firm productivity and managerial ownership is recognized by the capital markets, via high or low Q values.

2.2. The relationship of firm productivity to market value

A number of economic models postulate that the rate of productivity growth is an exogenous variable, which determines the equilibrium values of a set of endogenous variables including profits and/or stock prices. Allen et al. (1989) developed a two-sector general equilibrium model that links productivity growth with capital market performance. In their model, growth in equilibrium firm profits and in the value of a stock-price index are both increasing functions of the exogenous productivity growth rate. They argue that stock-price data could be used to make inferences about the rate of productivity growth in sectors, such as

services, for which the latter is difficult to measure directly. But given the high noise component in stock-price movements, when direct and reliable productivity measures are available, they are preferable. Baily and Schultze (1990) analyze the effects of an exogenous reduction in the rate of (labor-augmenting) productivity growth within a one-sector neoclassical growth model. They show that the decline in the productivity growth rate results in a decline in the rate of profit (equal to the marginal product of capital) both in the short run and (especially) in steady-state long-run equilibrium. Accordingly, differences between firms in TFP are likely to be positively correlated with differences in stock prices, productivity appears to be a more primitive or fundamental variable than market value. In this paper, we attempt to link productivity to the firm's market value.

2.3. Managerial ownership

The separation of ownership and control creates a potential conflict of interest between managers and shareholders. On one hand, giving more ownership to managers aligns their interests with shareholder interests. On the other hand, too much managerial ownership allows managers to become entrenched and to enjoy their private benefits of control. Mørck et al. (1988) point out that it is not possible, a priori, to predict which of these effects will dominate the other for a given managerial ownership level. Thus, the relationship between firm value and managerial ownership is largely an empirical issue.

Mørck et al. (1988) examine 371, Fortune 500 firms for the year 1980. They find a positive relationship between Tobin's Q and managerial ownership for the 0% to 5% board ownership range, a negative relationship in the 5% to 25% board ownership range (where managers are entrenched), and positive relationship for the > 25% board ownership range. They also tried different switch points and found that the 5% and 25% managerial ownership levels provided the best fit (in terms of the lowest sum of squared errors).

McConnell and Servaes (1990) examine 1173 firms for 1976 and 1093 firms for 1986. They find that Tobin's Q and managerial ownership are related in an inverted-U fashion, with the inflection point between 40% and 50%. Using this larger data set, they also find the downward sloping relationship to be less steeper than the upward sloping relationship. They also replicate the Mørck et al. (1988) piecewise linear specification and find no evidence for it.

Kole (1995) compares the 352, Fortune 500 firms common to Mørck et al. and McConnell and Servaes, and attributes the differences in their results for the 5% to 25% managerial ownership range to differences in the average size of firms included in their respective samples. In contrast, Demsetz and Lehn (1985) find no linear relationship between the accounting profit rates and ownership concentration for 511 large firms during 1980. Hermalin and Weisbach (1991) examine 142 NYSE firms for the years 1971, 1974, 1977, 1980 and 1983. They find Q increases until ownership reaches 1%, turns negative in the ownership range of 1%

to 5%, turns positive again in the ownership range of 5% to 20%, and then turns negative for ownership levels greater than 20%. Hubbard and Palia (1995) examine 172 mergers that occurred during the years 1985 to 1991 and find that the bidder's excess returns increase until ownership levels of 5% and turn negative thereafter. Denis et al. (1994) examine 1689 firms during the years 1985 to 1988, and find managers get entrenched at ownership levels of 1% or greater, since these managers experience lower turnover.

We observe that the relationship between firm value and insider ownership has been found to be nonlinear, with two caveats, namely, differences exist as to when the relationship becomes positive or negative, and the variable being explained (the dependent variable) is not necessarily common across studies. The first caveat seems of more importance given that an optimum ownership level for maximum firm value cannot be uniquely prescribed.

3. Data

We obtain the managerial ownership data from the annual proxy statements that each firm has to file with the SEC. Given that using the entire population is prohibitively costly, we create a sample that has no size bias (among publicly traded firms), no survivorship problems and is largely randomly selected. We begin by checking the population of firms on *Compustat* that have no missing data on sales, book value of capital and stock price for the three years 1982–1984. Rather than restricting our sample to the large Fortune 500 companies that have lower managerial ownership levels (since managerial ownership and size are negatively correlated), we used a random digit generator to select 600 firms. From these 600 firms, we chose only manufacturing firms (SIC code 2000 to 3999), because estimating production functions for other industries is difficult. This resulted in a random sample of 255 firms. We followed these firms for the 12 years 1982–1993, resulting in a panel set of 1823 data points. Given that some firms left our sample because of mergers and acquisitions or bankruptcies, this sample does not suffer from any survivorship bias (which would apply if, for example, we included only firms that were listed on Compustat in 1993). For these 1823 observations, we collected the percentage of stock owned by managers from the annual proxy statements filed with the SEC. The annual proxy statement gives the percentage of total shares outstanding owned by the firm's top officers and board members. All other firm-specific financial data were collected from the industrial, research and full coverage files of Compustat.

Table 1 presents some descriptive statistics for our sample. We observe that the average firm in our sample has annual sales of 1.6 billion dollars and a market value of equity of 1.1 billion dollars. However, the median values are much smaller, with sales of 111 million dollars and a market value of equity of only 68 million dollars. These statistics suggest that our randomly selected sample has a large proportion of small firms, much smaller than in any of the previous studies.

4. Empirical tests and results

4.1. Productivity

As described in Section 3, we begin our empirical tests by defining our productivity measure to be TFP. TFP for firm i, in industry j, at time t is

$$\gamma_{ijt} = \frac{Y_{ijt}}{f(L_{ijt}, K_{ijt})}. \tag{9}$$

We assume $f(L_{ijt}, K_{ijt})$ to be the familiar Cobb–Douglas functional form $L^{\alpha}K^{\beta}$, where α and β are the output elasticities of labor and capital, respectively. [2] Substituting the Cobb–Douglas into Eq. (9) and taking logarithms gives us

$$\ln Y_{ijt} = \ln \gamma_{ijt} + \alpha \ln L_{ijt} + \beta \ln K_{ijt}. \tag{10}$$

We estimate the above equation using a two-way, fixed-effects regression technique. [3] Specifically, each firm gets its own intercept and each year has a dummy variable. The inclusion of year-effects eliminates the need to deflate any of the dollar denominated variables. If $\ln \gamma_{ijt} = \theta M_{ijt} + \epsilon_t$, then the equation that we estimate is

$$\ln Y_{ijt} = \omega_i + \alpha \ln L_{ijt} + \beta \ln K_{ijt} + \theta M_{ijt} + \delta_t + \epsilon_t \tag{11}$$

where ω_i are the unobserved firm effects ($i = 1, \ldots, N$), M_{ijt} is the 1-year lagged percentage of the firm owned by its managers, δ_t are the year effects ($t = 1982, \ldots, 1993$), and ϵ_t is the error term. Output (Y) is defined as net annual sales (Compustat item number 12), labor (L) as number of employees (Compustat item number 29) and capital (K) as net annual property, plant and equipment (Compustat item number 8).

Table 2 presents our results when we use the 1-year lagged managerial ownership variable. The coefficients on the year and firm dummies are not reported. The first column presents the results for the entire sample. We note that the input share of labor is 0.70 and the input share of capital is 0.15, generally consistent with the estimates. of Solow (1957). We also find that changes in the lagged managerial ownership variable have a positive and statistically significant effect on changes in productivity. We find that this regression has an F-statistic of 646.4 which is statistically significant at the 1% level. A similar result is found

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[2] The Cobb–Douglas function is a first-order approximation that imposes unit elasticity of substitution between the two inputs. We also estimated the translog production function (which takes into account interactions between inputs) and found no significant changes in our results. This is consistent with the findings of Maddala (1979).

[3] Consistent with other empirical papers, we do not fully solve the endogeneity problem of inputs as described by Griliches and Mairesse (1995). In order to minimize the endogeneity problem, in some specifications, we lagged all our independent variables, and find no significant change in our results.

Table 1

Descriptive statistics

The sample consists of 1823 data points for 255 manufacturing firms during the years 1983 to 1993. The sample is randomly selected from Compustat and does not suffer from survivorship or large firm biases. Variable definitions and when possible their Compustat item number (in brackets) are given as follows: Sales = annual sales (12); Tobin's Q = market value of equity plus book value of debt plus book value of preferred stock divided by the replacement value of assets; capital = net property plant and equipment (8); employees = number of employees (29); managerial ownership = 1-year lagged value of the percentage of total outstanding shares owned by managers obtained from the annual proxy statements filed by the company with the SEC; research and development = research and development expenses (46) divided by the replacement value of assets; total debt = short term debt (34) plus long term debt (9) divided by the replacement value of assets; assets = total assets (6); and market value of equity = stock price at the end of the year (24) times the number of shares outstanding (25).

Variable	Mean	Median	Standard deviation
Sales[a] (S)	1601.53	111.19	6935.74
Tobin's Q (Q)	1.69	1.23	4.08
Capital[a] (K)	556.94	24.33	2215.67
Employees[b] (L)	9.85	1.08	32.18
Managerial ownership (M)	13.73	6.30	17.43
Ratio of research and development expense to replacement value of assets (R&D)	0.11	0.05	0.23
Ratio of total debt to replacement value of assets (D)	0.40	0.32	0.38
Assets[a] (A)	1730.07	98.87	10472.31
Market value of equity[a] (MV)	1109.92	68.18	3619.08

[a] In units of million dollars.
[b] In units of thousand.

from the high adjusted R^2. In order to minimize endogeneity issues, we also lagged the inputs of capital and labor, the results of which are given in the second column. We find no difference in the statistical significance of our independent variables, although the parameter coefficients on capital and labor both fall, whereas the parameter coefficients on managerial ownership rises. The goodness of fit (as captured by the F-statistic and the adjusted R^2) also falls.

We next split sample into two subsamples: a subsample that includes firms whose yearly change in managerial ownership is greater than the median yearly change in managerial ownership (of 1%), and the second subsample consisting of all other firms. We re-estimate our productivity regression for the first subsample of firms, i.e., firms whose yearly change in managerial ownership is greater than the median yearly change in managerial ownership. The results on the first subsample are given in the third and fourth columns of Table 2. We find that our estimates of input share of labor and capital remain basically the same, with the input share of labor falling slightly from 0.696 to 0.616. The managerial ownership coefficient for this subsample is twice the economic magnitude of the impact of managerial ownership on the entire sample, namely, 0.004 as compared to

Table 2

Production function estimates

The dependent variable is the logarithm of sales. Each firm gets it own intercept. The first two columns uses the entire sample, whereas the last two columns are for firms whose yearly change in managerial ownership is greater than the median change in managerial ownership for the whole sample. *t*-statistics are given in parentheses. Estimates of firm-effects and year-effects are not reported.

Independent variables	Full sample		Firms whose yearly change in managerial ownership > median yearly change	
Logarithm of capital	0.152* (8.55)	–	0.152* (5.83)	–
Logarithm of 1-year lagged capital	–	0.109* (5.11)	–	0.100* (3.08)
Logarithm of employees	0.696* (27.92)	–	0.616* (17.03)	–
Logarithm of 1-year lagged employees	–	0.697* (22.35)	–	0.646* (13.74)
One-year lagged percentage of the firm owned by managers	0.002** (2.04)	0.004* (3.24)	0.004** (2.44)	0.006* (2.86)
F-statistic	646.4	452.1	441.0	303.1
Adjusted R^2	0.992	0.987	0.994	0.991

*Significant at the 1% level.
**Significant at the 5% level.

0.002. This suggests that firms that experience larger than the median yearly increase in managerial ownership experience greater productivity gains in the following year. In column four, we present our results for our first subsample when we lagged all the independent variables. Once again, we find no difference in the statistical significance of our independent variables although the parameter coefficients on capital and labor both fall, whereas the parameter coefficients on managerial ownership rises. The goodness of fit (as captured by the *F*-statistic and the adjusted R^2) also falls.

The results of Table 2 suggest that managerial ownership changes are positively related to changes in productivity, and this sensitivity is higher for firms who have greater than the median change in managerial ownership. These results are robust to including lagged estimates of production inputs, year dummies, and separate dummies for each firm to control for unobservable firm characteristics.

Whereas the above results have included the lagged managerial ownership variable linearly, we know from the previous corporate finance literature that firm performance could be nonlinearly related to managerial ownership. In Table 3, we present the results of two nonlinear specifications that have been suggested in the literature, namely, the quadratic specification of McConnell and Servaes (1990), and the piecewise linear specification of Mørck et al. (1988). In column one, we include the lagged managerial ownership variable and the square of the lagged managerial ownership variable. If the true relationship between firm performance

Table 3

Production function estimates (nonlinear functional forms)

The dependent variable is the logarithm of sales. Each firm gets it own intercept. The first column is the quadratic specification and the second column is the piecewise linear specification of Mørck et al. (1988). If M is the 1-year lagged percentage of managerial ownership, the piecewise linear specification is specified as follows: $M_1 = M$ if $M < 5\%$, or $M_1 = 5\%$ if $M \geq 5\%$; $M_2 = 0$ if $M < 5\%$, or $M_2 = M$ minus 5% if $5\% \leq M < 25\%$, or $M_2 = 20\%$ if $M \geq 25\%$; $M_3 = 0$ if $M < 25\%$, or $M_3 = M$ minus 25% if $M \geq 25\%$. t-statistics are given in parentheses. Estimates of firm-effects and year-effects are not reported.

Independent variables		
Logarithm of capital	0.152* (8.55)	0.152* (8.56)
Logarithm of employees	0.694* (27.84)	0.695* (27.89)
1-year lagged percentage of the firm owned by managers	−0.002 (−0.76)	–
(1-year lagged percentage of the firm owned by managers)^2	0.000** (2.02)	–
M_1	–	0.000 (0.05)
M_2	–	0.000 (0.34)
M_3	–	0.003* (2.62)
F-statistic	633.0	630.2
Adjusted R^2	0.991	0.991

*Significant at the 1% level.
**Significant at the 5% level.

and managerial ownership is first increasing and then decreasing as in McConnell and Servaes (1990), we should find the coefficient on the lagged managerial ownership variable to be statistically significantly positive, and the coefficient on the square of the lagged managerial ownership variable to be statistically significantly negative. In fact, we find the opposite signs on both managerial ownership variables, with the coefficient on the lagged managerial ownership variable being statistically insignificant. The F-statistic for goodness of fit for this regression is

Table 4

Production function estimates (timing of managerial ownership)

The dependent variable is the logarithm of sales. Each firm gets it own intercept. t-statistics are given in parentheses. Estimates of firm-effects and year-effects are not reported.

Independent variables	If the % of the firm owned by managers is:		
	1-year lagged	1-year forward	Contemporaneous
Logarithm of capital	0.152* (8.55)	0.143* (7.82)	0.154* (8.62)
Logarithm of employees	0.696* (27.92)	0.798* (29.92)	0.695* (27.88)
Percentage of the firm owned by managers	0.002** (2.04)	0.002*** (1.91)	0.002*** (1.87)
F-statistic	646.4	624.4	634.1
Adjusted R^2	0.992	0.991	0.991

*Significant at the 1% level.
**Significant at the 5% level.
***Significant at the 10% level.

lower than the corresponding F-statistic of the linear specification in column one of Table 2. A similar result is found for the adjusted R^2. The lower goodness of fit, and the wrong signs suggest that the quadratic relationship (first increasing and then decreasing) is dominated by the linear relationship in our sample.

We next check the piecewise linear specification of Mørck et al. (1988). As before, to control for possible endogeneity, we use the 1-year lagged managerial ownership variable as the relevant managerial ownership variable. Similar to Mørck et al., we construct three variables M_1, M_2 and M_3 as follows.

M_1 = managerial ownership level if managerial ownership level is $< 5.0\%$,
      = 5.0 if managerial ownership is $\geq 5.0\%$;
M_2 = 0 if managerial ownership level is $< 5.0\%$
      = managerial ownership level minus 5.0 if $5.0\% \leq$ managerial ownership
        level is $< 25.0\%$,
      = 20.0 if managerial ownership is $\geq 25.0\%$;
M_3 = 0 if managerial ownership level is $< 25.0\%$,
      = managerial ownership level minus 25.0 if managerial ownership is
      $\geq 25.0\%$.

The results of such an analysis are given in column two of Table 3. As in Mørck et al., we find M_1 to be positively related to firm performance although it is strongly statistically insignificant. We also find M_2 to be positive and statistically insignificant, contrary to the negative and statistically significant relationship of Mørck et al. We find M_3 to be positive and statistically significantly related to firm productivity. The lower goodness of fit (when compared to the linear specification of Table 1) and the opposite and statistically insignificant sign of M_2, suggests that the linear specification better captures the relationship between managerial ownership and firm productivity than that proposed by the piecewise linear specification.

Hall and Liebman (1998) have found that large changes in share ownership are correlated with good firm performance. We hence check if managerial ownership lags, is contemporaneously related, or leads productivity. The results of such an analysis are given in Table 4. In column one, we present the productivity regressions using the 1-year lagged managerial ownership variable. This result is similar to that presented in Table 2, and is included to facilitate comparison with the results using the 1-year forward and contemporaneous managerial ownership variables. In column two, we use the 1-year forward managerial ownership variable. We find that the coefficient estimate on managerial ownership remains the same although its statistical significance falls. Further, both goodness of fit statistics (the F-statistic and adjusted R^2) fall. In column three, we use the contemporaneous managerial ownership variable. Once again, we find that the coefficient estimate on managerial ownership remains the same although its statistical significance falls, as does both goodness of fit statistics. These results

Table 5

The relationship between productivity and Tobin's Q

Regression of the Tobin's Q residuals on the productivity residuals which are obtained as follows. We get the productivity residuals ϵ_{ijt} from estimating $\ln Y_{ijt} = \omega_i + \alpha \ln L_{ijt} + \beta \ln K_{ijt} + \delta_t + \epsilon_{ijt}$, where ω_i are the firm effects ($i = 1,\ldots,N$), δ_t are the year effects ($t = 1982,\ldots,1993$), Y is defined as net annual sales (Compustat item number 12), K is net annual property, plant and equipment (Compustat item number 8) and L is number of employees (Compustat item number 29). We use two specifications for Tobin's Q. The first specification uses adjusted Q — that controls for three other variables, namely, the ratio of research and development expenses (Compustat item number 46) to the replacement value of assets, the ratio of total debt (Compustat item number 9 + Compustat item number 34) to the replacement value of assets, and the logarithm of the replacement value of assets. The second specification uses Q only and does not control for research and development expenses and total debt. The Tobin's Q residuals ϵ'_{ijt} are obtained from regressing Tobin's Q on other control variables, namely, $Q_{ijt} = \omega_i + \beta_1(\text{R\&D}_{ijt}/\text{RV}_{ijt}) + \beta_2(D_{ijt}/\text{RV}_{ijt}) + \beta_3 \ln \text{RV}_{ijt} + \delta_t + \epsilon'_{ijt}$, where R&D represents research and development expenses (Compustat item number 46), D total debt (Compustat item number 9 + Compustat item number 34) and RV the replacement value of assets. We then regress our Tobin's Q residual ϵ'_{ijt} on our productivity residual ϵ_{ijt}. t-statistics are given in parentheses. Estimates of firm-effects and year-effects are not reported.

	Productivity parameter	F-statistic	Adjusted R^2
Adjusted Q	1.247* (3.45)	11.88	0.011
Q	1.098* (3.20)	10.24	0.008

*Significant at the 1% level.

suggest that using the lagged managerial ownership variable to minimize endogeneity problems is appropriate because it has the strongest statistical significance and goodness of fit. At the very least, our results are not significantly impacted whether we use lagged, contemporaneous or forward managerial ownership levels.

We now turn our attention to examining the relationship between productivity and Tobin's Q. Tobin's Q is defined as the market value of the firm divided by the replacement value of assets of the firm. The numerator of Q consists of the market value of common stock, plus the book value of preferred stock and the book value of debt. In order to calculate the replacement value of assets we use the methodology described in Cummins et al. (1994). The average Tobin's Q in our sample is 1.69, with a median value of 1.23. All firms with Q values greater than 10 were omitted from our sample.

Similar to Mørck et al. (1988), we use two specifications. The first specification uses adjusted Q — that controls for three other variables, namely, the ratio of research and development expenses (Compustat item number 46) to the replacement value of assets, the ratio of total debt (Compustat item number 9 + Compustat item number 34) to the replacement value of assets and the logarithm of the replacement value of assets. The second specification uses Q only and does not control for research and development expenses and total debt. We begin by obtaining the residuals ϵ_{ijt} from estimating the following production function:

$$\ln Y_{ijt} = \omega_i + \alpha \ln K_{ijt} + \beta \ln L_{ijt} + \delta_t + \epsilon_{ijt} \tag{12}$$

where all variables are defined as before. We observe that these regressions control for firm-effects and for year-effects. Then, we obtain the residuals ϵ'_{ijt} from regressing (adjusted) Tobin's Q on other control variables, namely,

$$Q_{ijt} = \omega_i + \beta_1\left(\mathrm{R\&D}_{ijt}/\mathrm{RV}_{ijt}\right) + \beta_2\left(D_{ijt}/\mathrm{RV}_{ijt}\right) + \beta_3 \ln \mathrm{RV}_{ijt} + \delta_t + \epsilon'_{ijt} \tag{13}$$

where R&D represents research and development expenses, D total debt and RV the replacement value of assets. Consistent with Mørck et al. (1988), we find firms with higher research and development expenses, and higher debt levels have higher values of Q, whereas larger firms have lower values of Q (results not reported). We then regress our Tobin's Q residual ϵ'_{ijt} on the productivity residual ϵ_{ijt}, the results of which are given in Table 5.

In the first row, we present the adjusted Q results (i.e., controlling for research and development expenses and debt). We find a parameter coefficient of 1.247 which is strongly statistically significant at the 1% level. In the second row, we present results from a similar regression without controlling for research and development expenses and debt. Once again we find a strong positive relationship between productivity and Q that is statistically significant at the 1% level. These results suggest that the stock market rewards firms with increases in firm value when these firms increase their level of productivity.

5. Conclusions

Theory and some previous empirical studies suggest that managerial ownership may influence firm performance. Productivity is an important indicator of the performance of the firm. But few production-function studies have accounted for management ownership. Consistent with the corporate finance approach, this paper uses the ownership stake of a firm's managers as an argument in estimating the firm's production function. Accordingly, this paper brings together the corporate finance and productivity literature. Using a large sample of randomly selected manufacturing firms (1823 observations) that does not suffer from any survivorship or large firm size biases, we find that managerial ownership changes are positively related to changes in productivity. We also find a higher sensitivity of changes in managerial ownership to changes in productivity for firms who experience greater than the median change in managerial ownership. These results are robust to including lagged estimates of production inputs, year dummies, and separate dummies for each firm to control for unobservable firm characteristics. In addition, we find that the stock market rewards firms with increases in firm value when these firms increase their level of productivity.

This paper does not examine whether the current practise of awarding large amounts of stock options to managers also has a significant impact on firm

productivity. Further, we do not analyze the impact of the size and composition of the board of directors on firm productivity. We leave such issues for future research.

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