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# FIRM SIZE AND THE EFFECT OF PROFIT-SHARING

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## Introduction and Overview

Profit and gain sharing may play an important role in the reform and eventual privatisation of state-owned enterprises, as well as in private firms. In recent years there have been a number of pioneering empirical studies noting positive linkages between the presence of alternative compensation schemes (usually profit-sharing) and firm performance (usually measured by productivity). Studies in this literature include Fitzroy and Kraft (1987), Conte and Svejnar (1988), Estrin, Jones and Svejnar (1987), Fitzroy and Vaughn-Whitehead (1991). For a survey see Weitzman and Kruse (1990). An analytical framework for the econometric testing of this linkage is developed in Section II.

The purpose of the present study is to examine how robust these findings are in the face of careful controls on sample frame, selection and econometric specification. For, in our view, most previous empirical studies of the causes and effects of profit-sharing and related schemes, have been subject to several quite basic potential limitations. First, firms of the type included in these studies may be so "unusual" that such plans simply reflect various aspects of the firms' unusualness, rather than anything intrinsic about the plans themselves, either in terms of their causes or effects. Studies based on comparisons of alternative compensation schemes within labor-managed firms, perhaps a majority of studies in this literature, while extremely interesting, cannot be generalised to nonlabour-managed firms.[1]

Moreover, studies which combine one or a few firms from several diverse industries are combining unlike production technologies in a single estimation (at best utilizing dummy and interaction variables). When the profit-sharing plan is correlated with industry group, it is hard to know if one is drawing conclusions about the plan or the industry.[2] And only in few industries is profit-sharing (and related gain sharing and employee ownership schemes) more than a small minority practice (see, e.g., Freund and Epstein, 1984). Other characteristics not captured in the estimates, such as mandated co-determination in larger European firms,[3] a long history of cooperative industrial relations, or the role of profit-sharing as a pension system in profitable unionised firms,[4] may be more important than specific schemes in explaining productivity. In general, when firms with profit-sharing are outliers in their industry,[5] profit-sharing variables may reflect any aspect of the firm as an outlier.

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Efforts to predict the productivity or other performance impact of profit-sharing through estimates of the productivity impact of existing schemes in other firms is also subject to a selectivity bias problem. Those firms which have already adopted profit-sharing may reasonably be those for which the performances impact of profit-sharing will be among the greatest (Smith, 1988, p.47). It does not presuppose too much knowledge among managers to expect such a selection effect on average, and some degree of "evolutionary" market selection would amplify this correlation.

Perhaps most importantly, none of the published studies effectively control interactivity for firm size and profit-sharing, though the theoretical literature on free rider and moral hazard problems in teams strongly implies that profit-sharing should be more effective at smaller firm sizes (e.g., Holmstrom, 1982). In fact, almost all studies present only Cobb-Douglass specifications.

This paper is an effort to address these somewhat interrelated problems in the literature. First, we sample the computer industry, in which profit-sharing is not unusual in any sense. Evidence from an earlier survey (Smith, 1988), as well as anecdotal evidence from business and computer industry periodicals, suggested that profit-sharing and related plans are widespread; yet non-profit-sharing firms are also not outliers. The sample for the present study indicates that over a quarter of the firms in the computer industry meet a definition of profit-sharing corresponding to the microeconomics literature (see Section III, where we discuss the original data set developed for this study). Thus, we examine the productivity impact in a sample in which neither profit-sharing nor its absence is the outlier. Surveys were conducted to determine which firms practiced which type of profit-sharing plans. This information was combined with data on firm performance publicly available from the U S Securities and Exchange Commission.

In addition to a careful choice of a sample frame, we also subjected the results to a number of robustness checks. Careful specification tests were performed, as detailed in Section IV. Importantly, we allow for non-linearity in the specification of effects of profit-sharing. Finally in Section V, we draw general conclusions and interpretations of the findings and suggest fruitful directions for follow-up research.

**Analytical Framework**

The theoretical literature on the effects of profit-sharing has been sharply divided. On the one hand, it is widely argued that profit-sharing should improve employee incentives, promote harmonious industrial relations, and extend average tenure and thus positively influence firm-specific skill development (Freund and Epstein, 1984; Jones and Svejnar, 1985).

On the other hand, profit-sharing has been argued to be ineffectual because of free rider problems among who individually receive only a small share of their extra profits generated and have potentially negative effects of diluting the incentives of the "residual claimant" to monitor and enforce acceptable effort levels. In other words, profit-sharing could result in increased shirking by management as well as by workers (Jensen and Meckling, 1979).

Following the theoretical literature we allow that profit-sharing may affect firm performance through improving (or harming) motivation, cooperation and innovation.[6] The form and significance of any positive or negative effects is to be determined empirically. In the literature published to date, most reported results indicate a positive effect (for surveys see Weitzman and Kruse, 1990; Jones and Pliskin, 1991). Hypothesis testing in previous studies has been formulated as determining which of these opposing schools is correct. In contrast, since a cooperative game among employees, and between employees and managements, is easier to enforce in a smaller team size, our approach is to allow for positive effects in small firm or teams sizes and negative effects in larger ones.

We would summarise the large literature on profit-sharing as suggesting that it may have two types of performance effect. The first is a quantity of output effect reflecting higher effort. In addition to this quantity effect there may be a price effect, in that if the incentives of profit-sharing lead to higher quality merchandise may be expected to fetch a higher price on the market. In the present study, we use revenues as our performance measure, which should capture either of the effects individually or interactively (though we cannot determine the relative importance of the effects).

We assume that revenues net of material costs are influenced by the labour force size, the capital stock, and (possibly) the presence of profit-sharing. As discussed above, the introduction of profit-sharing may induce extra effort and output from the work force. The effect may be dampened for larger firms as free rider problems become increasingly likely. The larger the labour force, the harder to enforce a "cooperative solution" among the workers. In a noncooperative solution, there exists only the incentive to provide the fraction of marginal effort personally accruing to the individual employee as a profit share (see Sertel, 1982). In larger firms it is also harder to ensure a cooperative outcome between owners and management on one side and other employees on the other. In particular, in larger firms with many divisions, employees may reasonably fear that management will use transfer pricing between divisions to opportunistically reduce the large profit shares bonuses contracted to be disbursed to exceptionally profitably divisions (or those exceeding company targets by significant margins). Such abuses have been occasionally detected; and concern over them have been the subject of industrial relations disputs.[7] The presence of such collective bargaining conflicts might well amplify any negative net effects of profit-sharing at a larger scale of plan operation. Operationally, since data on individual worker effort is unavailable (if not inherently unmeasurable), we aggregate to the firm level and assume that any productivity augmentation may be observed in any combination of disembodied productivity effects or labour-embodied effects.

Without theory to guide the functional form specification for the production function (or more properly price times the production function) it is natural to use the mean-centered translog, as it is based on a second-order Taylor approximation of any such well-bahaved function. This function also offers the advantage of allowing directly for positive profit-sharing effects at small scales and negative effects at larger scales, a tenable interpretation of the theoretical literature taken as a whole, but one not tested for in the empirical literature to date. In fact, the transcendental logarithm revenue function is the form selected by the specification tests presented in Section IV. Since the translog does include the Cobb-Douglas and other specifications as special cases,we limit our presentation in this section to this specification.

In the translog specification, we have,

$$(1)\ R=B_o b_1 X+B_1 L+b_2 X.L+B^2 L^2+b_3 X^* L^2+B_3 K+B_4 K^2+B_5 L^* K+b_6 X^* L^* K+e$$

where R is the log of revenues, L is the log of the labour force, K is the log of real capital use, $B_o$ is (the log of) an intercept, and X is the dummy variable related to profit-sharing.[8] Note that specifications indicating only embodied or only disembodied effects are nested in (1); this is one of the sets of specification tests we perform below. Note also that because of the competing theoretical arguments that profit-sharing may lower productivity, one-sided hypothesis tests on the coefficients are appropriate. These tests are summarised in Table 1.

**Table 1: Summary of Hypothesis Tests**

| | |
|---|---|
| Disembodied productivity effects only: | |
| Null hypothesis | b1 = 0 |
| Positive effect | b1 > 0 |
| Negative effect | b1 < 0 |
| Labour-embodied productivity effects: | |
| Null hypothesis | $b_2 = b_3 = 0$ |
| Positive effect | $b_2, b_3 > 0$ |
| Negative effect | $b_2, b_3 < 0$ |
| Mixed effect | $b_2 > 0, b_3 < 0$ |
| Joint hypothesis test for disembodied and labour-embodied effects: | |
| Null hypothesis | $b_1 - b_2 - b^3 = 0$ |
| Positive effect | $b_1, b_2, b_3 > 0$ |
| Negative effect | $b_1, b_2, b_3 < 0$ |
| Mixed effect | $b_1, b_2 > 0' b_3 < 0$ |

As indicated by the table, we take as our null hypothesis, in each case, that profit-sharing will have no effect, positive or negative, on firm performance. Note that when we test jointly for embodied and disembodied effects, the coefficient for disembodied productivity effects may be either positive or negative, owing to the ambiguous effect of a slope interaction dummy variable on the measured intercept. Before presenting the results of the tests, we place them in perspective by describing the charateristics of the data set.

**The Data Set**

In this section, we describe the unique data set used for this study. We have 258 income statement observations on 86 firms, spanning three years in most cases. We also have two years data on balance sheets and other information on company performance. These are drawn from electronic versions of 10K reports filed with the SEC. In addition, we have collected supplemental information generally by telephone survey on the types and operation of profit-sharing and related plans in each of these firms, directly from the companies' human resource departments. The universe of firms considered for the study are the 372 publicly traded American companies which list either or both of two four-digit SIC codes, 3573, which corresponds to the hardware industry, and 7372, which corresponds to the software industry, as a primary business. Further details of the profit sharing institutions of firms in the data set are to be found in Bradley and Smith (1992).

**Incidence of profit-sharing**

Overall, of 258 observations on 86 firms, 27% have strong profit-sharing, which is the variable we use in the study, and 59% have either strong or weak sharing.[9] Among software firms, the breakdown is 32% and 65%. Among hardware firms, it is 24% and 55%. The incidence of *strong* plans at about a quarter of the sample is vastly higher than the apparent incidence of strong plans in industry generally (certainly no more than two per cent).

In sum, we sample a well-defined industry in which neither profit-sharing nor the absence of profit-sharing renders firms outliers. While one may say that there are other factors which make the computer industry unusual, the same could be said of most other industries. We thus have generated a universe of firms and a sample of the universe which is immune to certain selection bias criticisms including the problem of drawing generalisations from outlier firms.

**Financial Data**

We have no reliable, comparable data on indexes of price and quantity for the firms in the sample. Thus, we work with revenue functions. This approach allows us to capture a profit-sharing effect of increasing either output or quality (and hence price), though not to distinguish between them.

We use the flow measure of capital from the income statements. This enables us to use three years data for most firms. We have data on the labour force for each year.

## Some Descriptive Statistics

In Table 2, we present descriptive statistics. The profit-sharing firms in our sample appear to be somewhat smaller on average in revenue, assets and employment, but none of these differences are statistically significant. Some 57.1% of the profit-sharing firms are based in the hardware industry and the balance in the software industry; 66.5% of the non-sharing firms are based in hardware.[10]

**Table 2: Descriptive Statistics**

| Statistics | Firm Type | |
|---|---|---|
| | Profit-Sharing | Non-Sharing |
| Number of Observations | 57 | 152 |
| Average Revenues (thousands) | $ 684,000 | $ 868,112 |
| S D of Revenues (thousands) | 1,541,016 | 2,003,385 |
| Average Number of Employees | 8,082 | 9,982 |
| S D of Employees | 18,281 | 23,974 |
| Average Flow Use of Capital (thousands) | $ 43,596 | $ 71,989 |
| S D of Capital Use (thousands) | 99,721 | 215,551 |

## Econometric Findings

Most studies of this kind have begun with specification tests for the selection of the production function and then added the relevant qualitative variables for profit-sharing. In the present case, if we follow this approach we must compare a Cobb-Douglas revenue function with CES and translog specifications. The test of this hypothesis is given at the bottom of Table 3, in which the Cobb-Douglas specification is rejected at the 5 percent level. However, Table 3 also indicates that the Cobb-Douglas specification cannot be rejected the 1 percent level. Because of this result, and because of the widespread use of Cobb-Douglas specifications in the profit-sharing literature, we first test for profit-sharing effects in the Cobb-Douglas specification.

**Table 3: F-Tests**

| | Hypothesis | F-statistics Degrees of Freedom |
|---|---|---|
| 1 | $B_2 = b_3 = B_4 = B_5 = 0$ (i.e., Translog with all relevant PS dummies vs Cobb-Douglas with all relevant PS dummies) | 10.42**(4,192) |
| 2 | $b_1 = b_2 = b_3 = 0$ (i.e., That profit-sharing durmmies are jointly insignificant in the Translog specification) | 11.94**(3,192) |
| 3 | B2 = B4 = B5 = 0 While constraining $b_1 = b_2 = b_3$ (i.e., That Cobb-Douglas is preferred over Translog specifications while constraining all PS variables to equal zero). | 3.52*(3,195) |

** Significant at 1% level

* Significant at 5% level

**Table 4: Regression Results Cobb-Douglas Specification**

| Variable | Coefficient (t-statistic) |
|---|---|
| Intercept | -.075* (-2.371) |
| Labour | .630** (19.851) |
| Capital | .272** (11.332) |
| PS Intercept Dummy | .138* (2.264) |
| PS Labour Interactive Dummy | .049+ (1.577) |
| $R^2$ = .954 | |

** Significant at 1% level

* Significant at 5% level

\+ Significant at 15% level

Table 4 shows that adding embodied and disembodied profit-sharing dummies to the Cobb-Douglas specification generates positive and significant effects. Our results thus generally conform to the positive effect found in the literature, when this procedure is followed.

This approach, however, is based more on convention than economic or econometric theory. Where economic theory postulates that variables should be included in a regression, excluding these variables from specification tests implies that the tests are being performed over a set of mis-specified equations and are thus of questionable value. To remedy this potential difficulty we also pursue an alternative, a more theory-oriented programme, in which we include the embodied and disembodied profit-sharing variables in the original specification, before the specification tests are performed. The results of this approach are given at the top of Table 3, where it is shown that the Cobb-Douglas specification can be rejected at both the 5 percent and 1 percent levels. In addition, Table 3 presents evidence that indicates the rejection of the null hypothesis that the profit-sharing variables are, by themselves, jointly insignificant. This approach thus leads to the selection of the translog function with all profit-sharing variables included and the estimation of that equation is presented in Table 5.[11]

**Table 5: Regression Results Translog Specification**

| Variable | Coefficient (t-statistic) |
|---|---|
| Intercept | -.216** (-5.592) |
| Labour | .619** (17.366) |
| Labour Squared | .039* (2.167) |
| Capital | .248** (9.104) |
| Capital Squared | .021** (2.790) |
| Cross Product | -.024 -(1.189) |
| PS Intercept Dummy | .398** (5.207) |
| PS Labour Interactive Dummy | .092** (3.125) |
| PS Labour Squared Interactive Dummy | -.069** (-5.181) |
| - $R^2$ = .961 | |

** Significant at 1% level
* Significant at 5% level

The results show that profit-sharing is significantly and positively associated with revenues, operating through both embodied and disembodied effects. Note that the terms in labor and capital control for any scale effect. Since a control for hardware versus software firms proved statistically insignificant, it is dropped from the final regression form (without consequence). The negative embodied coefficient in labour squared is examined in detail below.

For a firm of average factor use, we get above average revenues with the presence of profit-sharing (40% more sales, so that the findings are economically as well as statistically significant). Moreover, revenues increase more for a given increase in labour use with profit-sharing in place than without it. This advantage increases at a decreasing rate, however, and after some number employees, productivity is actually higher without profit-sharing. For interpretation of the results, note that profit-sharing firms in the sample are otherwise smaller than firms without profit-sharing.

The final regressions results in Table 5 confirm the positive intercept dummy variable reported so regularly in the profit-sharing literature. Moreover, there is strong evidence for an embodied labour effect, which corresponds to a majority of those earlier studies which have considered this possibility.[12] But the coefficient on the slope dummy for the labour-squared term is also significant at the 1% level — and it is negative. In order to interpret these results, consider separate estimated equations for the profit-sharing and non-profit-sharing samples.

For firms without profit-sharing, the estimated equation is:

$$\ln Q = -.216 + .619 \ln L + .248 \ln K + .038 \ln L^2 + .021 \ln K^2 - .024 \ln L \cdot \ln K$$

For firms practising profit-sharing, including the estimated coefficients on dummy variables, the estimated equation is:

$$\ln Q = .182 + .711 \ln L + .248 \ln K - .027 \ln L^2 + .021 \ln K^2 - .024 \ln L . \ln K$$

To calculate the level of labor at which profit-sharing has its maximum positive effect, we differentiate the estimated equations with respect on lnL and set the results equal to find,

or, $\ln L = .69$; and so $L = 2$ workers. Thus profit-sharing is computed to have its *maximum* impact in a firm as small as 2 employees.

To compute the point at which the *net* effect of profit-sharing turns negative, we set the estimated equations equal to find,

$$0 = .398 + .02 \ln L - .065 \ln L2.$$

Solving for lnL, $\ln L = 3.29$, or, $L = 27$.

In other words, profit-sharing is estimate to improve performance in the sample upto a firm size of only 27, and to actually decrease it thereafter.

We would caution against placing too much emphasis on these point estimates. We would stress, however, that our *qualitative* results conform to predictions from theory and argue strongly that our findings are likely to point this growing and important literature in a fruitful direction. For example, the sample includes a significant number of smaller firms the study years were difficult ones for the computer industry, and the sample size could be larger.

## Conclusion

This study has demonstrated that work force size matters in determining the sign and significance of the firm performance by utilizing a unique data set from a carefully chosen sample frame, and following systematic sample selection procedures which allowed for the possibility of the size effect. The standard production specification in the profit-sharing literature, the Cobb-Douglas, rules out this type of size effect. Our results confirm the widely noted positive disembodied productivity effect of profit-sharing, and identifies a positive labour-embodied effect, but finds a negative embodied effect in the log of labour squared. Point estimates indicated a net negative effect at relatively small firm sizes.

It would be premature to draw definitive conclusions from the results of one study. But pending further investigations, if the results of the present study continue to hold, a potential implication of the work is that profit-sharing (or targeted gain sharing) should be operated at reasonably small unit sizes. Large firms can plausibly gain the maximal benefits of profit or gain sharing by breaking groups into productivity centers which reflect actual work teams, where employees can more easily overcome free rider problems, observe directly the metric on which the sharing rule is based and establish confidence that the calculation of their profit share will not be subject to accounting opportunism.

The best way for this research programme to proceed would be a reconsideration of data sets already used in other studies to allow for diminished or negative effects of profit-sharing at larger scales of operation. This could be tested using methods other than the translog specification, such as split samples or such specifications as the quadratic function, and considered before ruling out such an effect by setting on a production function such as the Cobb-Douglas before evaluating relevant qualitative variables. Other attempts should be made to develop data sets addressing the economic and econometric problems that this one was developed to address. To facilitate this next step, we will arrange to make the data set developed for the present study available to researchers in this field and we would encourage other investigators to do likewise.

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## Endnotes

01. For example, Jones and Svejnar (1985), Estrin, Jones and Svejnar (1987), and Defourney, Estrin and Jones (1985) all use data sets from labour-managed industrial cooperatives in Europe. These data sets have been the only ones publicly available which include information on the percent of bonus pay in total compensation and similar variables. These firms differ from non-labour-managed firms in a multitude of ways; comparing various formal schemes for disbursal of current profits within such firms may tell us little about such effects in conventional firms.

02. Indeed, Conte and Svejnar (1988), in a pioneering study combining data on diverse firms, appeal to an industry group problem in explaining the calculated negative impact of direct worker ownership on productivity. Other observed positive effects are thus in relation to <u>these</u> firms. Similar observations apply to other papers.

03. Fitzroy and Kraft (1987) find that profit sharing is more common among the larger firms in their sample from West Germany, the most important case of codetermination. Board-level codetermination is required only of larger firms, and shopfloor codetermination is concentrated in larger firms.

04 E.g., this problem might apply to the otherwise excellent study of Kruse (1992).

05. Perhaps because of a higher technical requirement for firm-specific human capital and higher turnover costs.

06. For a quite varied series of analyses explaining the incentives underlying the frequently observed positive profit sharing-productivity linkage compare Conte and Svejnar (1988), Fitzroy and Kraft (1987), Freund and Epstein (1984), Sertel (1982), Smith (1988) and Weitzman (1984).

07. For example, the 1985 dispute between the United Auto Workers Union and Reynolds Aluminum Company over its Grand Rapids plant profit sharing plan, in which a federal arbitrator found in favor of the union, in part.

08. For a full derivation of this approach see Griliches (1967), and for relevant applications see Brown and Medoff (1978) and Jones and Svejnar (1985).

09. A close study of each firm's reported profit sharing plans revealed that in most cases the plans clearly fell into one of two types, only one of which corresponds to profit sharing as defined in the microeconomic literature. For this "strong" profit sharing, firms announce a predictable share of profits to be divided among employees and distributes profits in cash on a quarterly, twice-yearly or annual basis. For "weak" profit sharing, the firm announces a bonus at the end of the year which may be only loosely and often not at all tied to profitability and which funds a pension or defines the employer match for an employee savings program (usually a 401K plan). We stuck to a strong definition of profit sharing, to be consistent with the microeconomic literature,and to avoid the criticism of some previous work that profit sharing studies were merely showing the better performance of firms with sufficient internal rents to afford a defined contribution pension plan. (Firms which had both types of plan were classified as strong sharers). Note that in standard reports of the incidence of profit sharing, weak and strong sharing are reported together (for example, DOL, Employee Benefits in Small and Large Firms, 1982; 1986. See also Freund and Epstein,1984). Typical incidence of weak sharing in U S industry is about 10%. The weak profit sharing incidence in the current survey is close to that reported in an earlier survey of high tech, high growth firms (Smith, 1988).

10. When firms were reasonably balanced between the hardware and software fields, we classified them as hardware firms.

11. Note that this is the same specification that would have been estimated in the first approach, at a 95 percent level of confidence.

12. See, e.g.,Jones and Svejnar (1985).