Does Size Really Matter? Empirical evidence on group incentives.

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Abstract

The paper empirically analyzes the economic theory and intuition that the "free rider" problem will overwhelm firm-wide incentives in large firms. Kandel and Lazear (1992) claim that in a simple model of an equitable partnership, Nash equilibrium e□ort levels fall with the number of partners - the $\frac{1}{N}$ problem. The paper shows that this result is crucially dependent on a unstated assumption on the production function. In particular, if worker e□ort levels are complementary, e□ort levels can increase with the number of partners. This di□erence may explain the empirical finding that the $\frac{1}{N}$ problem is substantial in medical and legal practices (where e□ort levels are independent), but less important in manufacturing (where e□ort levels are complementary). The empirical results suggest that the use of firm-wide incentives increases with firms size, at least for smaller firms. The results do *not* support the claim that the use of other human resource practices, like self-managed work teams, allows the firm to mitigate the $\frac{1}{N}$ problem.

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1 Introduction

The use of profit sharing amongst production line workers in large manufacturing firms, seems to defy economic logic. According to Kandel and Lazear

(1995); Prendergast (1999)). Gaynor and Gertler (1995) shows that proxies for doctor's e□ort decrease as the number of doctors in the practice increases. However, the empirical evidence on the relationship between firm size and the use of profit sharing in manufacturing (and other industries) is not nearly so clear. As stated above, a number of studies have found that firm-wide incentives schemes lead to productivity improvements, even after accounting for the selection problems inherent in such measures (Boning et al. (2001); Knez and Simester (2001)). Boning et al. (2001) point out that this result suggests the free rider problem is not overwhelming, at least not in steel mini-mills.

Studies on the adoption of profit sharing using establishment and firm level data are inconclusive. Using Canadian firm level data, Jones and Pliskin (1997) find that larger firms are *more* likely to o□er employee share ownership to all non-managerial employees and profit sharing to production workers, contradicting the standard intuition. Drago and Heywood (1995) analyze the adoption of incentive schemes in Australian establishments. The authors do find that profit sharing schemes are less likely to be used by larger firms, although the estimated coe□cient is not statistically significantly di□erent the analyze8320(an)-

the other hand, it seems likely that e□ort levels are complementary. For example, on a production line, if one worker is shirking or becoming careless, the productivity of workers further down the line will be adversely a□ected. It seems likely that the size of a manufacturing firm is intimately related to the degree with which worker's e□orts are complements. The analysis of the bonus scheme at Continental suggests that interdependence is important. The scheme introduced by Continental gave all workers in the firm a bonus if a firm-wide target of on-time departures was achieved. According to Knez and Simester (2001)

> A flight cannot depart until the entire ramp and gate activities have been performed, so that poor performance by one employee can negate good performance by the rest of the group. For example, maintenance or fueling delays will prevent a flight from leaving on time, even if passengers and baggage are loaded... (p. 766)

It is also the case that breakdowns at one airport will a□ect the ability of other airports to contribute to achieving the company wide target (especially in a hub-spoke system).

There are two other arguments made in the literature regarding why the $\frac{1}{N}$ problem is not overwhelming for firms using profits sharing plans. The first is that there are economies of scale in adopting incentive schemes such as profit sharing or employee share ownership. This would occur if there were substantial fixed costs or large overhead in implementing these schemes. It seems reasonable to expect that only larger firms are going to o□er employee share ownership. Jones and Pliskin (1997) suggest that at least part of the explanation for their results lies with the existence of scales economies, particularly given the administrative costs of employee share ownership schemes.

The second is that firms use human resource management practices, such as self-managed work teams that allow for "mutual monitoring" (Knez and Simester (2001); Pliskin (2000)). According to Knez and Simester (2001),

> To explain why the [group incentive] scheme may have been e□ective we argue that the organization of employees into autonomous

> work groups[4] enabled Continental [Airlines] to induce mutual monitoring among employees within each group. (p. 743)

Che and Yoo (2002) present a theoretical model of group incentives in a repeated game that formalizes the argument made in Weitzman and Kruse (1990). The authors show that the implicit incentives generated by perfect (within group) monitoring and repeated interaction allow the free rider

e□ect on the free rider problem. This argument is similar to the argument made below that the relationship between group size and free riding is dependent on the relationship between group size and the production function. Other experimental evidence suggests that average giving actually *increases* in group size (Isaac et al. (1994)).

The rest of the paper proceeds as follows. Section Two presents a simple theoretical analysis of the relationship between firm size and worker e□ort choice. The section presents the empirical implications of this model. The section also presents the empirical implications of the economies of scale hypothesis and the mutual monitoring hypothesis. Section Three presents the empirical evidence. The section discusses the data and tests the hypotheses. Section Four concludes.

2 Theoretical Analysis of Group Incentives

This section has three parts. The section presents a theoretical model to illustrate how the number of employees is related to individual e□ort choices under a simple firm-wide incentive scheme. The implications of this model are illustrated using a linear latent profit model of the firm's decision to use firm-wide incentives. The implications of economies of scale are also illustrated using this model. The section also analyzes the value of using firm-wide incentives conditional upon the use of other human resource management practices such as self-managed work teams, that allow for mutual monitoring. A linear latent profits model is used to illustrate the implications of the

such that $C(0) = 0$, $C' > 0$ and $C'' > 0$.[7]

The production function is $f : <^{\infty} \; ! \; <$. For a firm with N workers $f(e_1; e_2; :::; e_N; :::)$ is such that for all $i > N$, e_i is a constant such that $9M \; 2 <$ such that $f < M$. The partial derivative on i's e□ort is positive ($f_i > 0$), and there is diminishing returns in

Proof. From Equation (1), $e_i^*(N)$ is the solution to

$$\frac{®e_i^{®-1}\Pi_{j\neq i}e_j^®}{N} \; ¡ \; e_i = 0 \tag{2}$$

By symmetry, the Nash equilibrium is such that $e_i^* = e_j^* = e^*$ for all $i; j \; \cdot \; N$. Therefore $e^* = \left(\frac{N}{®}\right)^{\frac{1}{N®-2}}$. QED.

If for some range of N, ® is large enough, then Nash equilibrium e□ort levels will increase as more workers are hired. How "large" ® needs to be de-

It is therefore not obvious that the value of using profit sharing decreases monotonically in firm size.

2.2 A Model of Firm Choice of Profit Sharing

In a simple linear latent profit model there exist two possibilities, the latent value of each is presented below. Let V_P be the latent value to the firm, where $P \in \{0, 1\}$ indicates whether the worker is provided with profit sharing. First, the value of not using profit sharing is denoted by A_{ij} for worker i and firm j. The latent profits of the other contract will be compared to this one.

$$V_0 = A_{ij} \tag{3}$$

The value of using profit sharing is V_1.

$$V_1 = A_{ij} + g(N_j) + X_i\bar{}_{iP} + X_j\bar{}_{jP} + \varepsilon_{ijP} \tag{4}$$

where N_j is the number of workers in firm j, g is some function of N_j, X_i is a vector of observable characteristics of the worker, X_j is a vector of observable characteristics of the worker's firm, and ε_{ijP} represents unobservable characteristics that affect the relative value of using profit sharing. If $g(N_j) = \bar{}_N N_j$ or $g(N_j) = \bar{}_N \log(N_j)$, then the $\frac{1}{N}$ problem exists if $\bar{}_N < 0$. A result that $\bar{}_N > 0$ would be consistent with the hypothesis that there are complementarities in the production process and effort levels increase with firm size. This result would also be consistent with the existence of economies of scale.

2.3 A Model of Firm Choice of Profit Sharing and Teams

Consider the linear model presented above. Now assume that the firm can choose to use two human resource management practices, profit sharing ($P \in \{0, 1\}$) and teams ($T \in \{0, 1\}$), where are either self-managed work teams or quality circles or both. The value of these two practices is denoted V_{PT}. First, the value of neither using profit sharing nor groups is denoted by A_{ij}. The latent profits of the other contracts will be compared to this one.

$$V_{00} = A_{ij} \tag{5}$$

Hypothesis 1 *Mutual Monitoring*
i) $\bar{}_{NP} + \bar{}^{*}_{NPT} = 0$
ii) $\bar{}_{NP} < 0$

Part (i) of Hypothesis 1 follows the reasoning of ?) and states that if teams are used by the firm, then the value of profit sharing will be una□ected by the size of the firm. Part (ii) is the same as the traditional $\frac{1}{N}$ problem, but now with the condition that the firm does not use teams.

3 Empirical Evidence on Group Incentives

3.1 Data

The empirical analysis presented below uses data from the Canadian Workplace and Employee Survey (WES) 1999. WES 1999 surveyed management and up to 12 employees at 6,358 establishments with a response rate of around 95 %. There are 24,938 employee surveys, which is a response rate of 83 %. It is important to realize that this is establishment level data, and that there may be more than one establishment per firm. There are two concerns. First, the measure of size may be not be accurate. This issue is discussed further below. Second, the standard errors may be larger than shown because it is not possible to tell whether two establishments are actually members of the same firm, and thus not independent observations. For a more detailed discussion of this issue see Jones and Pliskin (1997).

In order to reduce the variation in the type of establishments and workers that are analyzed, the samples are limited to full-time production workers[11] in non-government manufacturing establishments. This restriction substantially reduces the sample size.[12] The restriction is particular important for understanding what is meant by the use of "teams" or "circles". In a broader sample that includes non-production workers or non-manufacturing firms, it

Variable	*Mean*
PROFIT SHARING	.13
TEAM	.54
Full-Time Workers	374 (660)
MALE	.78
EXPERIENCE	7.49 (7.91)
SKILLED	.81
UNION	

3.2 Results

Table 2 presents the main empirical results of the paper. The table shows that the traditional $\frac{1}{N}$ problem is not supported by the data. The hypothesis implies that the coefficient on the log of the number of employees is negative. From Column 2, the coefficient is,

$$\bar{}_{NP} = .15 > 0 \tag{12}$$

and statistically significantly different from 0. This result indicate that production workers in large establishments are (if anything) *more* likely to receive profit sharing than workers in small establishments. This is consistent with the claim that there are complementarities in the production function and with the argument that there are economies of scale.

Column 4 presents the results with the assumption that $g(N_j) = \bar{}_N N_j + \bar{}_{N^2} N_j^2$. The coefficient is

$$\bar{}_{N2P} = -.0000002 < 0 \tag{13}$$

which is negative and statistically significantly different from 0. The results suggest that for Canadian establishments with over 4,000 full time workers, the free rider problem becomes overwhelming and the probability of using profit sharing decreases in establishment size. A possible explanation for this result is that there is a free rider problem and there are also economies of scale in the adoption of profit sharing. For smaller firms, economies of scale dominate free riding, and for larger firms, free riding dominates economies of scale. Alternatively, it seems reasonable that complementarities will diminish with firm size, and eventually the addition of new workers is not enough to induce greater effort.[15]

The last hypothesis to be tested in this section is the mutual monitoring hypothesis. The estimator used to test this hypothesis accounts for the endogeniety in the decision of the firm to give a worker both profit sharing and place that worker in a self-managed work team or quality circle. The estimator is discussed in detail in Adams (Forthcoming, 2002). The estimator allows the firm's choice on giving a worker profit sharing and teams to be

[15] It seems that for academic papers in economics, this number is around 2.

Profit Sharing	*Model 1* —	% Δ	*Model 2* —	*Model 3* —
Log(N)	.15	.02	-	-
	(.07)	(.01)	-	-
N	-	-	-.00004	.0008
			(.00008)	(.0002)
N^2	-	-	-	-.0000002
			-	(.00000005)
Male	.18	.02	.25	.25
	(.16)	(.02)	(.16)	(.15)
Experience	.02	.002	.02	.01
	(.01)	(.001)	(.01)	(.01)
Skilled	.23	.03	.08	-.07
	(.23)	(.03)	(.21)	(.19)
Quality	-.05	-.01	.10	-.04
	(.50)	(.08)	(.55)	(.51)
Union	-.33	-.05	-.08	-.26
	(.24)	(.04)	(.21)	(.21)
Custom	.09	.01	.19	.21
	(.30)	(.04)	(.34)	(.30)
Canadian Born	.62	.07	.64	.63
	(.21)	(.02)	(.20)	(.21)
High School	-.07	-.01	.06	.00
	(.15)	(.02)	(.16)	(.15)
Constant	-2.97		-2.52	-2.38
	(.48)		(.50)	(.48)
Log Likelihood	-389.77		-401.20	-382.38
Sample Size	1,390		1,400	1,400

Table 2: Probit Regressions on Profit Sharing (Robust Standard Errors)

made simultaneously, and it allows the two choices to interact. The model's key characteristics is that it allows this interaction to vary from worker to worker in observable and unobservable ways.

Table 3 presents the estimates from the complementary Probit. From the data, the equations are respectively (from column 2, row 3 and 19)

$$\bar{}_{NP} + \bar{}^{*}_{NPT} = .14 + .01 = .15 > 0 \tag{14}$$

which is positive rather than 0, and (from column 2, row 3)

$$\bar{}_{NP} = .14 > 0 \tag{15}$$

which is also positive and statistically significantly different from 0. That is, for workers not in teams, larger establishments are *more* likely to receive profit sharing the workers in smaller establishments. These results are *not* consistent with the Mutual Monitoring Hypothesis. This hypothesis posits that $\bar{}_{NP} < 0$ and $\bar{}_{NP} + \bar{}$

Model 3	$\bar{\ }$	*Robust SE*
Profit Sharing($\bar{\ }_P$)		
Log(N)	.14	(.05)
Male	-.07	(.18)
Quality	.87	(.29)
Experience	.01	(.01)
Skilled	.19	(.21)
Candian Born	.59	(.21)
Constant	-3.59	(.47)
Team($\bar{\ }_T$)		
Log(N)	-.06	(.05)
Male	.23	(.12)
Quality	-.29	(.25)
Experience	.0135	(.0076)
Skilled	.61	(.17)
Candian Born	.22	(.12)
Constant	-.29	(.30)
Both($\bar{\ }^*_{PT}$)		
Log(N)	.01	(.05)
Qualit		

production function is separable in the effort level of each worker, then the intuition holds. However, if there are complementarities, more workers may *increase* effort levels under equitable partnership incentive schemes. This difference in production functions, may explain why the $\frac{1}{N}$ problem seems to hold in legal and medical partnerships, but does not seem to hold in manufacturing firms. Empirical results from a recent Canadian survey of production workers and their establishments, does not support the notion that firm size is negatively related to the adoption of firm-wide incentive schemes. The results suggest that (at least for smaller firms), as firm size increases the adoption of profit sharing and employee share ownership also increases.

Another possible explanation is that large firms use human resource man-

would increase with the number of workers and profit sharing may be more profitable for larger firms. The second is that there are economies of scale in the use of profit sharing and employee share ownership plans.

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