Rank vs Money: Evidence from Managers*

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Abstract

We study the existence and relative importance of status concerns compared to financial incentives among managers in a large firm where the bonus is determined through a high powered tournament. Using detailed data about both performance and labour input decisions, we consider managers' response to feedback about their rank as well as monetary bonuses. We find that managers exhibit rank concerns that are distinct from, but co-exist with, financial performance incentives. These rank concerns are important: moving from the bottom to the top of the firm's ranking is worth up to $4,500 a year to the average manager, or 48% of their annual performance bonus. Moreover, managers exhibit desire to catch up (i.e., utility is concave in rank): when managers get a bad rank they respond by improving performance, rather than getting discouraged. Our data allow us to identify these effects using both outputs (performance) as well as inputs (staffing decisions) of the managers.

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1 Introduction

Understanding motivation in the workplace is fundamental for academic economists and practitioners alike. Whilst traditionally economists have focused on financial incentives, more recently a growing amount of attention is being devoted to non-monetary factors, such as intrinsic motivation, recognition, esteem and concerns about performance relative to peers. Nevertheless, the evidence on how non-monetary motivations operate in real world workplace, particularly in presence of financial incentives, remains scarce. In their literature survey Ellingsen and Johannesson (2007) warn that when it comes to the fundamental question of 'Why do people work?', most of the evidence on non-monetary motives comes from 'a context without monetary rewards, which is obviously different than a workplace that offers a combination of the two.'[1]

In this paper we provide evidence on persistent non-monetary motivations in the field, using a sample of store managers who also face high-powered monetary incentives. Analyzing six years of non-experimental data from a food and drink chain, we make four contributions. First, we show that managers display a particular form of non-monetary motivation – concern about their performance rank in the firm's quarterly league tables. These rank concerns are distinct from, but co-exist with, financial performance incentives the managers face.

Second, we compare the relative importance of (marginal) financial incentives and rank concerns. Although marginal financial incentives play some role, we find that rank concerns are a more consistent motivator of manager performance and decisions. Where we are able, we quantify and compare the magnitude of their impacts on performance and manager utility. Our data show that the prospect of going up 1 rank in league tables containing around 80 managers leads to a 10-fold improvement in managerial performance compared to the prospect of raising the bonus by $1. Interpreted through the

[1] As we will discuss later, a small number of papers addressing this gap have appeared since.

lens of our theoretical model, moving from being the bottom to being the top manager in the country is worth \$4500 a year to an average manager, which is equivalent to 48% of their performance bonus[2].

Our third contribution is to show that the utility that managers derive from rank is concave in rank. As argued in the theoretical literature on relative performance concerns, the shape of utility has crucial policy implications: if you tell someone they have low rank, an individual with convex utility over rank would be more inclined give up, while one with concave utility would work harder (see, for example, Clark and Oswald, 1998[3]). Hence, concave utility implies that rank concerns reduce the dispersion in manager performance within the firm.

Our final contribution is the fact that we can analyze these claims using not just outcome measures (e.g. store profit) but measures of manager's inputs (e.g. staffing decisions). Thus, unlike many other studies we can directly analyze the behavioral response of managers rather than relying on noisy downstream measures of output.

Three key features of our dataset make the results particularly relevant and compelling. First, when answering the question 'why do people work?', managers are a particularly important group as they lead and motivate others. Second, the firm we study has had its current reward and rank system for a long time, and so we provide evidence of long-run steady state behaviour, which typically eludes experimental interventions. Third, although the non-experimental nature of our study comes at a cost of reduced control, the rich detailed data allow for careful and nuanced empirical identification.

To elaborate on the last point, it is hard to study the combined presence of monetary and non-monetary motivations in the field, not least because disentangling the effects of the two can be difficult but also due to other

[2]As we describe in section 2, the firm varies the number of leagues from tournament to tournament. So whilst on average, a league table contains 80 managers, the largest league table used by the firm, that for the entire country, contains 180-290 managers, depending on the time period.

[3]It is worth noting that in Clark and Oswald (1998), the agents care about cardinal, not just ordinal, differences in performance.

challenges. The following features of our design allow us to overcome them.

First, the main way in which our firm evaluates and recognizes manager performance is a quarately performance tournament. This tournament confers both monetary rewards (bonus) and status onto the managers, by ranking them in public league tables. Thus, it is the ideal setting to study both types of motives. Between tournaments, the firm publishes interim league tables as feedback for the managers. We develop a theoretical model to show that, in our setting, close to the tournament, the observed response of the managers to the feedback contained in the interim league tables will depend on their unobserved motives: i.e. whether they are motivated by monetary incentives, status concerns, or both. We derive testable predictions and take them to the data on how managers respond to the last interim feedback they receive, two weeks before the tournament.

Second, the reason why in our setting monetary and non-monetary motives lead to different observable response is the way that the firm calculates manager bonuses. Once the managers are ranked, their ranking is divided into bands, with everyone in the same band receiving the same bonus. This means that bonus changes discretely at band boundary. Hence, heading into the last two weeks before the tournament, managers who are the closest to the boundary face the steepest financial incentives (in expectation). This way, arguably arbitrarily drawn band boundaries generate exogenous variation in the strength of financial incentives. Furthermore, incentive strength oscillates with rank and the resulting non-monotonic relationship between rank and financial incentives (i.e. the marginal monetary returns) helps us identify whether the manager is pursing status concerns or a greater bonus. As we show in our theoretical framework, this feature implies that the two motives predict different patterns in manager response to interim feedback, forming the heart of our identification strategy.

Third, the strength of our results is underpinned by the rich and detailed panel data on roughly 530 managers. Crucially, we observe two key (according to the firm) but very different dimensions of manager performance — profit, and service. In additional to absolute performance, the firm issues separate manager rankings on each of these two measures. Also, and this is very rare, we observe two key inputs directly linked to managerial decisions: labour and average product of labour. These decision variables affect the two performance measures differently – for example, more labour input is typically good for service but not for profit – allowing us to construct nuanced tests.

Using both performance and managerial decisions data, we show that manager actions reveal rank concerns, generated by a utility function concave in rank. In other words, managers demonstrate desire to catch up. First, they improve performance on the measure in which they fall behind their peers, even if this does not lead to an increase in their bonus. Second, managers make different decisions, depending on which measure they fall behind: for example, they increase labour only when they fall behind on service; when they fall behind on profit they instead increase average product of labour.

Our paper contributes to the growing literature on motivation in the workplace. There are numerous models of non-financial motivation, and substantial laboratory evidence. However, as is clear from surveys such as Ellingsen and Johannesson (2007), Gneezy et al. (2011) and Kamenica (2012), what is missing is the evidence from the actual workplace.

The focus of our study is potential co-existence and relative importance of monetary and non-monetary motivations. Here, predictions of theoretical models depend on details. For example, Bénabou and Tirole (2003) and Ellingsen and Johannesson (2008) expect non-monetary motivations to be crowded out by financial incentives whilst Auriol and Renault (2008) argue the two will re-inforce each other. Our paper speaks to this literature by showing that, in the long run, non-monetary incentives, and more specifically status or rank concerns, can co-exist with the financial ones. Furthermore, we show that, in a time window where the managers can increase pay by around 3% by improving performance, the managers still care strongly about their rank, and may pursue the latter and not the former.

Although this paper is non-experimental it relates to a small number of field experiments, which analyze how workplace performance is affected when the firm introduces relative performance feedback alongside existing financial incentives. Their results do not paint a consistent picture: some show an improvement in performance (Blanes i Vidal and Nossol, 2011), others a decline (Barankay, 2012), while the third group finds that whether there are effects and/or their direction depends on other factors (Ashraf, 2022, Delfgaauw et al., 2014).[4]

Our paper makes several key contributions. First, not only do we see clear motivating effects of league tables, but, since we analyze several years worth of data from the firm that has used league tables for a long time, we show that these effects can persist into the long term, forming part of steady state behavior.[5] In this respect, our paper is close to a non-experimental study by Ager et al., 2022 who show how personal rivalry and status concerns motivated performance and risk taking among World War II pilots.[6] Second, we not only analyze manager performance, but also labour decisions that are under managers' direct control and which are linked to expected performance in very specific ways. This allows us to derive more robust results, something that is not usually possible when agents' behaviour is inferred from performance alone (a standard feature of this literature). Third, we use a theoretical model to back out from the data the relative importance of financial and non-financial motivations in manager utility function. Fourthly, we find that response to rank is non-linear and concave, with low ranking managers exhibiting desire to catch up rather than discouragement[7],[8]. Finally, we study motivation among

[4]The question of how introduction of relative performance feedback affects performance has also been explored in the lab (Eriksson et al., 2009, Azmat and Iriberri, 2016) and in settings that do not involve financial incentives, again with somewhat mixed results (Azmat et al., 2019, Azmat and Iriberri, 2010, Ashraf et al., 2014, Bursztyn and Jensen, 2015).

[5]Most studies that look at introduction of relative performance feedback can only analyze its short term effect. The two exceptions, Ashraf et al. (2014) and Azmat et al. (2019), both in settings that do not have financial incentives, disagree on whether the effects of such interventions persist.

[6]In contrast, our paper examines the existence of rank concerns in a regular workplace, a setting that is arguably central to most people's existence, and studies the interplay of rank concerns and financial incentives.

[7]Of course, our sample is of people who voluntarily choose to work in a firm that ranks employees, and this should be taken into account when generalizing.

[8]The two relative performance feedback interventions in the field that allow for non-linear response, Azmat et al. (2019) and Bursztyn and Jensen (2015), both in educational settings without financial incentives, also show results that are roughly consistent with a concave

managers, rather than rank and file employees, which is arguably important in itself because the motivation of managers can have implications not just for their performance, but also for that of their underlings.

One implication of our findings is that to properly understand how relative performance concerns operate in the workplace, one needs to engage with ideas from the theoretical literature on status concerns (see surveys by Weiss and Fershtman, 1998, Heffetz and Frank, 2011 and Robson and Samuelson, 2011), and particularly the fact that shape of the utility over rank may not be linear (Clark and Oswald, 1998, Robson, 1992, Dekel and Scotchmer, 1999, Bisin and Verdier, 1998, Robson, 2001, Samuelson, 2004, Hopkins and Kornienko, 2004). This, in turn, has important implications for how rank concerns shape decisions in the workplace, for the optimal strategy of the firm, and for researchers' ability to identify this empirically. Hence, we see our paper as a step in bridging the gap between experimental literature on relative performance feedback on the one hand and the literature on status concerns on the other[9].

We describe our setting in more detail in Section 2. In Section 3 we develop a simple model that relates both performance and input decisions to monetary and rank concerns, and use it to derive several testable hypotheses. In Section 4, we take these hypotheses to our dataset, and present the results. Section 5 concludes.

2 Context

We study the behavior of, and feedback provided to, a set of store managers in a large food and drink chain. Each manager runs one store and has overall

utility function. In contrast, a laboratory experiment by Gill et al. (2019) randomly breaks rank ties to create exogenous rank variation and finds that subjects respond by working harder at high and low ranks relative to the middle ranks. Inter alia, such non-linearities may explain why it has been hard to get a consistent picture with interventions: if utility functions are non-linear in rank, heterogeneous effects of introducing rank may make it hard to predict the net effect.

[9]Along side estimating rank and incentive effects of a tournament, we also show that managerial performance improves across the board as the tournament day nears. This is consistent with findings such as Oyer (1998) and Kaur et al. (2015) who show performance often improves towards the pay date.

responsibility for it. The stores prepare most of the food that they sell on the premises. An average store has about 14 employees at work at any given time. As demand fluctuates on short term basis, a typical store also has around 50% (i.e., around 7) additional workers on its books, that can be asked to come in at a fairly short notice and are typically on part-time contracts. In the store, employees are divided into two groups: those who prepare food and those who serve the customers.

The manager decides on the overall labour required and on the allocation of labour across the two tasks, food production and service. As we will explain later, we can observe overall labour and have a proxy for division of labour across the two tasks.

The firm regularly measures several aspects of manager performance. In this paper, we focus on two of them, profit and service. This pair is interesting because of a key trade off: allocating more labour to service lowers profit. Also, these measures feature prominently in determining the managers' bonuses, as we explain in the next section[10].

2.1 Incentive scheme

The managers are paid a base salary as well as a substantial quarterly performance bonuses. The size of the bonus is determined by the end-of-quarter tournament, based on cumulative performance over the quarter. The average bonus is roughly 20% of the base salary, while the top bonus is about 150% of base salary. Thus, managers face substantial incentives to understand the scheme and make decisions that lead to higher bonuses.

The details of the bonus scheme are key to our empirical identification. The firm calculates the bonus using four performance measures: sales growth, profit relative to target, service, and regional manager evaluation. The bonus is calculated by aggregating the four store performance measures, using the following procedure:

[10] For the purpose of bonus calculations, the firm uses a profit measure that excludes variables clearly outside the manager's control and is adjusted across stores to account for store characteristics, levelling the playing field. For more details see Section 4.

1. For each performance measure i, managers are ranked, and each manager j gets a rank r_{ij}.

2. For each measure i, the constructed ranking is divided into bands. Within each band b, all managers get assigned the same score s_{ijb}. The score is higher for higher bands (near the top of the ranking).

3. A manager's bonus B_j is given by multiplying her four scores

$$B_j = \prod_{i=1}^{4} s_{ijb}$$

   Then all bonuses are normalized, and the final figure represents a percent of a manager's salary.

4. Each managers also receives an overall ranking $R_j = \text{rank}(B_j)$. A few managers at the very top of overall ranking get an additional bonus.

Steps 2 and 3 imply that, for a given performance on other measures, the manager's bonus is a step function of performance on measure i, as shown in Figure 1 for Q2 2014 profit data[11].

As we can see from the graph, the profit score and therefore the manager's bonus jump as their profit crosses a band border. Hence, the strength of incentives (i.e. the marginal monetary return to improvement in profit) oscillates with profit[12]. At the same time, rank changes monotonically with profit. Of course, the same is true for service. As we further discuss in Section 4, this generates different predictions for manager behaviour depending on whether it is driven by financial rewards or by status concerns.

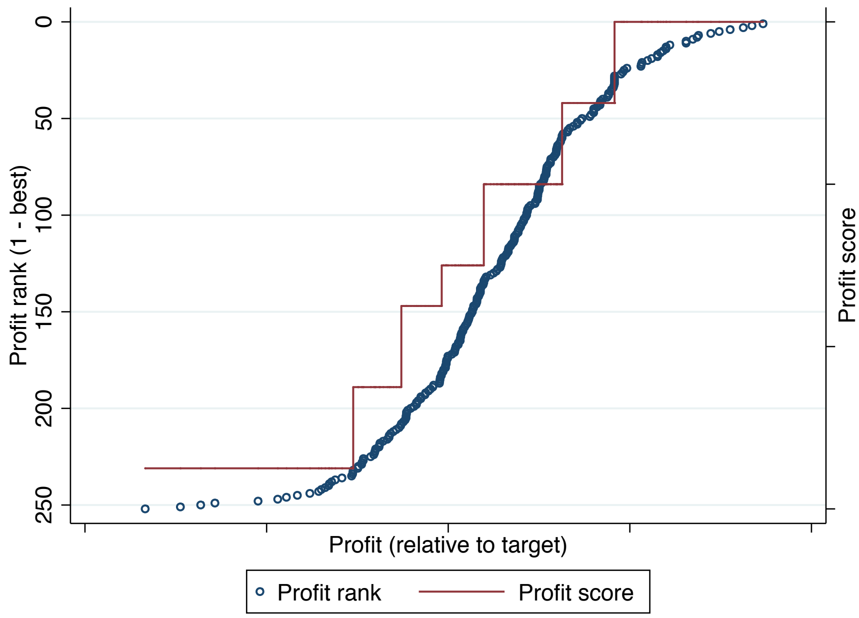
2.2 Information and feedback

The rules of the tournament are explained to the managers when they join the firm. When the actual tournament is held at the end of each quarter, each

[11] The rank axis in Figure 1 is reversed so that the best (lowest) ranks are at the top.

[12] The median size of the jump is 3 percentage points, a sizeable increase on a 20% average bonus rate. More on this is in Appendix B.

Figure 1: Profit rank and score



manager receives a table listing the results for all managers, in the order of their rank, with top ranking managers first. There is also often an event for all managers where the results are announced and top ranking managers are congratulated. Hence, it is reasonable to assume rank confers status in this firm.

Key to our analysis is that before the actual tournament managers get feedback on their performance in a similar format to the final tournament results. This feedback is weekly, in the first eleven weeks of a typical thirteen week quarter. The feedback takes the form of the results of a hypothetical tournament based on managers' cumulative performance so far that quarter. Each manager gets five tables, one for each of the four performance measures (sales, profit, service, and area manager evaluation) and a summary table.

In each table covering a particular measure, all stores are listed in the order of rank on this measure (r_{ij}), as in the hypothetical example for service in Table 1 (we cannot disclose an actual feedback table due to confidentiality agreements). Absolute performance (ρ_{ij}) and score (s_{ijb}) are also reported,

Table 1: Example of feedback table for service

Store	Service ρ_j	Service rank r_j	Score s_{jb}
.	.	.	.
.	.	.	.
.	.	.	.
D	88	10	x
E	86	11	x
F	85	12	x
G	84	13	z
H	82	14	z
I	81	15	z
J	80	16	z
.	.	.	.
.	.	.	.
.	.	.	.

making it easy for the store manager to see whether they are close or not to the border of the bonus band, i.e. the point where their score jumps. In our example in Table 1, $x > z$ and the manager of store G will see they are immediately below a higher bonus band.

We focus on managers' responses to the feedback they receive in week 11 of the quarter, in other words the last interim feedback given, two weeks before the actual tournament. For each performance measure, this feedback gives two key pieces of information to our manager.

The first one is performance-specific rank. This, as shown in Figure 6 in Appendix G.2, gives the manager a relatively accurate indicator of the rank they will get in the actual tournament. The second piece of information is the strength of financial incentives that the manager faces going into the last two weeks before the tournament. Intuitively, the strongest monetary incentives will be experienced by the managers who find themselves just below or just above a border of a bonus band in week 11.[13] This result is well known in the

[13]The former, like our manager G in Table 1, only needs a small effort to increase their bonus, and the latter might drop in bonus as a result of only a small shock. To corroborate

theoretical literature on tournaments.[14] The link between proximity to the border and financial incentives is particularly strong for week 11 feedback. In contrast, in earlier weeks, when the actual tournament is far away, proximity to the bonus border does not carry the same information. Hence, we focus on week 11 feedback and study manager reactions to it in the last two weeks of the quarter[15].

3 Theoretical model

We now turn to describing a theoretical framework that allows us to understand expected relationships between our observable variables and interpret the regressions that follow. More details on these variables and their measurements are in Section 4.

Our goal is to understand the optimal choice of observed inputs, as well as the induced performance, for each of two tasks, service and profit, when managers may care about both financial rewards and status. We imagine in the background there is an (unmodelled) set of other managers, which the manager under consideration is ranked against.[16]

In order to help build intuition we will begin by developing a simple model which generates our main behavioral implications, which are Observations 1-3. In order to more closely match the empirical specification, we then show how

this intuition with the data, we show that the managers who are nearer the border in week 11 are more likely to cross it; furthermore, only a tiny handful of managers manage to cross more than one boundary in the last two weeks. For more detail, see Appendix C.

[14]Although our simple model developed in Section 3 ignores strategic interaction, we show it is also true in a simple equilibrium setting in Appendix I. More generally, this intuition is well known from the literature on contests and strategic tournaments, beginning with Lazear and Rosen (1981). Furthermore, Casas-Arce and Martinez-Jerez (2009), Aoyagi (2010) and Ederer (2010) show that this result has a natural application to tournaments with intermediate feedback, similar to our setting.

[15]In our conversations with the firm and managers, it was clear that the last two weeks of the quarter are special: the end of the feedback is symbolic and signals the shift of manager's focus from possible other objectives to the end of the quarter tournament. In line with this, we see that, on average, managers improve their performance on the measures that feed into the tournament in the last two weeks of the quarter (for more details, see Appendix D).

[16]Thus, we assume that the utility function our agent is maximizing takes into account the equilibrium behavior of everyone else.

to enrich the model to allow for additional considerations, and which leads to Observation 4.

The model we develop in this section is that of a single decision-maker maximizing utility given an environment. In other words, it is partial equilibrium. One can think of this as capturing the behavior of an agent who is maximizing the payoff from their rank and monetary bonuses against a set of other agents who are uniformly distributed in their outputs at the end of a period, such that an agent, regardless of their choice, is always in the interior of the ranking. As such, this model works less well as an approximation for agents who are at the top or bottom of the distribution, when outputs are not uniformly distribution, or when there are relatively few agents.

In Appendix I we actually consider an equilibrium model with a continuum of agents that allows us to demonstrate how Observations 1 and 2 easily generalize, as would Observation 4. On the other hand, the precise prediction of Observation 3 does not necessarily generalize. Although the relative size of coefficients in our regression will still reflect the relative size of rank versus monetary concerns in utility, as demonstrated in Observation 3 the precise mapping will depend on the distribution. Section I works out an example when the distribution over outputs is uniform.

3.1 A simple model

We suppose there are two time periods: the time period up until week 11, denoted $t = 1$; and weeks 12-13, denoted $t = 2$. Because we focus only on Period 2 behavior, we drop the subscript t for all variables other than rank (described below) and assume that they are for $t = 2$. We take behavior in Period 1 as given.

We observe two inputs. The first is total labour bill, which we denote ϕ_1 and to which we will refer as labour for short. The second is the value of food produced by the store divided by total labour bill, which we denote ϕ_2, and refer to as output per worker. Ceteris paribas, when the manager allocates more labour to service, output per worker declines. So, although we do not observe the allocation of labour across production and service directly, output per worker can serve as a proxy for it[17]. Going forward we use $i = 1$ for variables related to labour and service, and $i = 2$ for those related to profit and output to worker.

We also observe managers' actual performance (in addition to their rank) in service and profit, which we denote ρ_1 and ρ_2 respectively. Performance is a function of observable inputs (ϕ_i): $\rho_i = a_i\phi_i$ with $a_i > 0$. In other words, we assume that increases in labour improve service, whilst increases in output per worker improve profit.

Workers receive a ranking at the end of every period. The ranking in Period t, $r_{i,t}$, depends on the ranking yesterday $r_{i,t-1}$, today's performance in task i (which itself is a function of observable and unobservable inputs today), and a constant term:

$$r_{i,t} = \rho_i + \beta_i r_{i,t-1} + \gamma_i = a_i\phi_i + \beta_i r_{i,t-1} + \gamma_i \tag{1}$$

where $\beta_i > 0$ but γ_i could be positive or negative (since if one doesn't put in input, it could be that rank falls). Note that a larger $r_{i,t}$ means better performance, in that an individual has performed better than more individuals.

We also assume that for each observable input managers faces a convex, quadratic cost function in its provision: $c_i(\phi_i) = \zeta_i\phi_i^2$ where $\zeta_i > 0$.

Managers receive monetary payoffs from a bonus scheme, and these payoffs depends on their rank. We consider a bonus function, $\omega_i(r_{i,t})$. As we discuss in Section 2.1, in reality ω_i is a step function. In order to incorporate it into our regressions we will assume it has the following properties: $\omega_i'(r_{i,t}) = 0$, in the case that $r_{i,t}$ is far away from a "step" in the bonus function, and $\omega_i'(r_{i,t}) = \Delta$ when $r_{i,t}$ is "close" to a step, where Δ is the extra bonus earned by crossing into the next bonus band.[18] Formally, we define a set of points $\bar{r}_1 ... \bar{r}_m$, and

[17]Of course, output per worker can also change for reasons other than a change in labour allocation; for example, if the productivity of labour allocated to food production improves.

[18]In reality, the increase in bonus caused by moving between two adjacent bands varies by which two bands are under consideration and whether $i = 1$ or 2. However, the actual differences are small, and we see no behavioral variation due to these differences, and thus we take an average and use this as Δ.

a distance ς. If $r_{i,t}$ is within ς of $\bar{r}_n$ for any n, then it is "close" to a step. In other words, if $|r_{i,t} - \bar{r}_n| \leq \varsigma$ for any $n = 1, ..., m$ then we say $r_{i,t} \in \mathbb{C}$, where $\mathbb{C}$ is the set of ranks close to a step. To simplify notation when taking first order conditions, we will denote $\omega_i'(r_{i,t}) = \Delta w_i$, where w_i is an indicator variable that is an implicit function of rank which either takes on a value of 1 (if $r_{i,t} \in \mathbb{C}$) or 0 (if $r_{i,t} \notin \mathbb{C}$).[19]

We suppose that individuals might also receive utility directly from their rank, where utility gained is a concave function of the rank — in particular that utility is a quadratic function of rank

$$-z_i(d_i - r_{i,t})^2 + \kappa_i$$

where d_i is strictly larger than the largest possible $r_{i,t}$, $z_i > 0$, and κ_i can either be positive or negative. Thus, a increase in rank leads to higher utility (i.e. utility that is less negative), and an increase in rank also leads to lower marginal utility.

To summarize, a manager's utility function in any given dimension is the sum of utility from rank, monetary bonuses and cost of effort provision,

$$U = \sum_i -z_i(d_i - r_{i,t})^2 + \kappa_i + \omega_i(r_{i,t}) - \zeta_i \phi_i^2 \tag{2}$$

Denoting $k_i = d_i - \gamma_i$, and substituting in for rank, the individual then maximizes an overall utility of

$$U = \sum_i -z_i(k_i - (a_i\phi_i + \beta_i r_{i,t-1}))^2 + \kappa_i + \omega_i(a_i\phi_i + \beta_i r_{i,t-1} + \gamma_i) - \zeta_i \phi_i^2$$

The first order condition with respect to ϕ_i is $2z_i a_i(k_i - (a_i\phi_i + \beta_i r_{i,t-1})) + \Delta w_i a_i - 2\zeta_i\phi_i = 0$. This implies that

[19] Thus, we assume that far away from a step, improvement in ranks do not improve the chance of getting a larger bonus. Close to a step, improvements in rank cause a constant improvement in the chances of getting a higher bonus.

$$\phi_i = \frac{a_i}{2z_i a_i^2 + 2\zeta_i} \left(\Delta w_i - 2z_i\beta_i r_{i,t-1} + 2z_i k_i\right)$$

The first term inside the parentheses on the right hand side is the effect of wages, the second the effect of rank, and the third is a constant.

We can rewrite this in terms of performance in task i, ρ_i, by simple substitution:

$$\rho_i = \frac{a_i^2}{2z_i a_i^2 + 2\zeta_i} \left(\Delta w_i - 2z_i\beta_i r_{i,t-1} + 2z_i k_i\right)$$

This simple model highlights the first three key intuitions which we will discuss here.

Observation 1 *The effect of previous rank in i on both input and current rank in i is negative.*

Observation 1 is that the effect of past rank in task i on current performance and input for task i should be negative (i.e. the regression coefficient on past rank in task i, when current performance or input in task i is the dependent variable is negative). This is because in our framework, we assumed that the return to rank is concave and so the marginal return to rank is decreasing in rank. This implies that as previous rank in a task increases, the return to increasing the rank via the observable input in that task falls, decreasing the observable input and outcomes.

We may be concerned that our approach has assumed that the return to rank is concave. In fact, under very mild conditions the coefficient on previous rank being negative is *diagnostic* of concavity in the utility from rank. To see this, suppose our model assumed the returns were convex instead, so that utility is

$$U = \sum_i z_i(a_i\phi_i + \beta_i r_{i,t-1})^2 + \kappa_i + \omega_i(a_i\phi_i + \beta_i r_{i,t-1} + \gamma_i) - \zeta_i\phi_i^2$$

Then the first order condition is $2z_i a_i(a_i\phi_i + \beta_i r_{i,t-1}) + \Delta w_i a_i - 2\zeta_i\phi_i = 0$.

In order to guarantee an interior solution, it needs to be that the second order condition is negative, or $2z_i a_i^2 - 2\zeta_i < 0$.

Solving out, we obtain

$$\phi_i = \frac{a_i}{2\zeta_i - 2z_i a_i^2} \left(\Delta w_i + 2z_i \beta_i r_{i,t-1}\right)$$

where the coefficient is positive rather than negative. Thus, if the return to rank is convex, we would in fact expect to observe the opposite relationship between past rank and current inputs and outcomes.

Of course, with convexity of the return function there could be another case: no interior solution is optimal. In this case it is always optimal to either have the highest rank or the lowest rank (which depends on the model parameters). Individuals with a low cost of supplying the input, or who care more about rank, should choose to go for the highest rank, as opposed to the lowest rank, more often. If either (i) the probability of obtaining a higher rank, conditional on the input level, is increasing in current rank, or (ii) a high past is indicative of parameters where a high rank gives higher utility than a lower rank, then we should observe a positive correlation between $r_{i,t-1}$ and both ρ_i and ϕ_i. Again, this is the opposite prediction of our Observation 1.

We now turn to our second observation, which considers the effect of the monetary bonus.

Observation 2 *The effect of the bonus in task i on both input and current rank in i is positive.*

Observation 2 is that we find that the effect the bonus in task i on current performance and input for task i should be positive. This is intuitive — as wages in task i go up, workers should be more motivated in that task (and so outcomes should go up).

Observation 3 *The ratio of the effect of $r_{i,t-1}$ to the of w_i on either input i or current rank in i is equal to $\frac{-2\beta_i z_i}{\Delta}$.*

Observation 3 notes the tight quantitative relationship that helps measure the magnitude of preference for rank relative to money. In a regression where either current performance in task i or inputs for task i are the dependent variable, the ratio of the coefficient on $r_{i,t-1}$ to the coefficient on w_i is equal to $\frac{-2\beta_i z_i}{\Delta}$. This ratio is proportional to the product of the effect of past rank on current rank (β_i) and the relative weight on rank-based utility compared to monetary based utility (z_i).

Of course, the fact that these observations hold precisely is due to the simple linear structure of the regression equation, and thus indirectly, due to the quadratic assumptions on the utility and cost functions. Violations of these assumptions will naturally weaken the observations.

3.2 Enriching the model

Although our simple model provides clean intuitions regarding the relationship between past rank and current inputs rank, it does so at the cost of leaving out many important features. For example, it neglects the fact that devoting resources to one task will typically take away resources from the other task. Similarly, there may be alongside observable inputs, there may be unobserved input decisions made by managers. In this subsection we first enrich the simple model with more realistic assumptions. We then show that the intuitions developed using the simple model in the previous subsection extend to this more realistic model. Moreover, we show that the enriched model also delivers an additional testable prediction.

We make two modifications to the model in the previous subsection. First, we now assume that there are no explicit costs to increasing the observable inputs ϕ_1 and ϕ_2. Instead we embed a trade-off by supposing that labour ϕ_1, and output per worker ϕ_2 are constrained by a linear technology constraint $g\phi_1 + f\phi_2 = C$, for a constant C. This captures the fact that, ceteris paribus, increasing labour will decrease output per worker.

Second, in addition to output being affected by observable inputs (ϕ's), we will also allow it to be affected by costly unobservable effort which we will denote e_i. Specifically, we assume that $\rho_1 = a_1\phi_1 + \psi_1 e_1$ and $\rho_2 = a_2\phi_2 + \psi_2 e_2$, where $a_i \geq 0$. The cost of effort is quadratic: $h_i e_i^2$.

The manager now maximizes the following utility function by choice of ϕ_i and e_i:

$$
\begin{aligned}
U &= -z_1(k_1 - (a_1\phi_1 + \beta_1 r_{1,t-1} + \psi_1 e_1))^2 + \kappa_1 + \omega_1(a_1\phi_1 + \beta_1 r_{1,t-1} + \gamma_1 + \psi_1 e_1) \\
&- z_2(k_2 - (a_2\phi_2 + \beta_2 r_{2,t-1} + \psi_2 e_2))^2 + \kappa_2 + \omega_2(a_2\phi_2 + \beta_2 r_{2,t-1} + \gamma_2 + \psi_2 e_2) \\
&- h_1 e_1^2 - h_2 e_2^2
\end{aligned}
$$

Recall that ϕ's are observable inputs that the researcher can observe, while the e's are unobserved by the researcher. Rank and wages, as well as the ρ's are also observables. The rest of the parameters are unobserved preference parameters.

We can again derive regression equations, by substituting the constraint on inputs into the main equation, taking first order conditions with respect to the relevant inputs, and solving the system of equations defined by the first order conditions. This generates equations that define ϕ_i. We can then do a change of variable using our definitions of $\rho_{i,t}$ and then solve out the new system of equations. For the details please see Appendix A. This process generates two pairs of equations which we can use for our empirical specification, relating both observable inputs as well as observable performance in both dimensions to past rank and wages.[20]

The first set of equations helps us understand the effect of the parameters on observable outputs — service and profit.

[20] In order to simplify the exposition of the equations, we make several substitutions.

- $A_1 = h_1 + \psi_1^2 z_1$ and $A_2 = h_2 + \psi_2^2 z_2$
- $B_1 = a_1 h_1 z_1$ and $B_2 = a_2 h_2 z_2$
- $E_1 = B_2 A_1 g(a_2 C - f k_2) + B_1 A_2 f^2 k_1$ and $E_2 = B_1 A_2 f(a_2 C - g k_1) + B_2 A_1 g^2 k_2$
- $E_{S,1} = (a_1 A_2 B_1 f^2 + a_2 \psi_1^2 B_2 g^2 z_1) k_1 + a_1 a_2 h_1 h_2 z_2 g(a_2 C - f k_2)$ and $E_{S,2} = (a_2 A_1 B_2 g^2 + a_1 \psi_2^2 B_1 f^2 z_2) k_2 + a_1 a_2 h_1 h_2 z_1 f(a_1 C - g k_1)$
- $D = a_2 B_2 A_1 g^2 + a_1 B_1 A_2 f^2$

$$\rho_{1,t} = \frac{a_1^2 A_2 h_1 f^2 + a_2 \psi_1^2 B_2 g^2}{2D} \Delta w_1 - \frac{a_1^2 A_2 h_1 f^2 + a_2 \psi_1^2 B_2 g^2}{2D} 2\beta_1 z_1 r_{1,t-1} - \frac{a_1 a_2 h_1 h_2 f g}{2D} w_2 + \frac{a_1 a_2 h_1 h_2 z_2 f g}{2D} 2\beta_2 r_{2,t-1} + \frac{2E_{S,1}}{2D} \quad (3)$$

$$\rho_{2,t} = -\frac{a_1 a_2 h_1 h_2 f g}{2D} \Delta w_1 + \frac{a_1 a_2 h_1 h_2 f g}{2D} 2\beta_1 z_1 r_{1,t-1} + \frac{a_2^2 A_1 h_2 g^2 + a_1 \psi_2^2 B_1 f^2}{2D} w_2 - \frac{a_2^2 A_1 h_2 g^2 + a_1 \psi_2^2 B_1 f^2}{2D} 2\beta_2 z_2 r_{2,t-1} + \frac{2E_{S,2}}{2D} \quad (4)$$

The second set of equations can be interpreted as understanding the effect of the parameters on observable inputs: labour and output per worker.

$$\phi_1 = \frac{\frac{B_1}{z_1} A_2 f^2}{2D} \Delta w_1 - \frac{2B_1 A_2 f^2}{2D} \beta_1 r_{1,t-1} - \frac{\frac{B_2}{z_2} A_1 f g}{2D} w_2 + \frac{2B_2 A_1 f g}{2D} \beta_2 r_{2,t-1} + \frac{2E_1}{2D} \quad (5)$$

$$\phi_2 = -\frac{\frac{B_1}{z_1} A_2 f g}{2D} \Delta w_1 + \frac{2B_1 A_2 f g}{2D} \beta_1 r_{1,t-1} + \frac{\frac{B_2}{z_2} A_1 g^2}{2D} w_2 - \frac{2B_2 A_1 g^2}{2D} \beta_2 r_{2,t-1} + \frac{2E_2}{2D} \quad (6)$$

Importantly, Observations 1-3 discussed above all still hold true in our enriched model.

Remark 1 *Observations 1-3 are still true in the enriched model.*

Our enriched model also generates a new prediction, related to the cross-effects of rank. The prediction is intuitive: being low in $r_{i,t-1}$ causes you to devote more inputs and effort to task i, being low $r_{j,t-1}$ causes you to devote fewer inputs and less effort to task i.

Observation 4 *The coefficients on $r_{1,t-1}$ and $r_{2,t-1}$ are of opposite sign.*

We now use equations (1)-(4) as the basis for our empirical exercise, and look for evidence of our four observations.[21] We also use the data to identify

[21] In addition to Observations 1-4 the model also generates additional predictions. However, these predictions depend on the specific assumptions embedded in our utility and cost functions, and so we do not highlight them here.

the relative size of different preference parameters to the extent it is possible. For the most part, because of the limited nature of our data, we can only set identify the parameters. We explore this further in section 4.3.

Although Observation 3 makes a prediction about the relationship between the coefficients on past rank and wage, our model is very flexible about the relative impact of many other features of the environment. For example if we compare the equations defining ϕ_1 and ρ_1 (or ϕ_2 and ρ_2) we would typically expect the relative size of the coefficients on w_1 compared to w_2, and the relative size of the coefficients on $r_{1,t-1}$ to $r_{2,t-1}$ to change. This tells us that the relative effect of past rank (or wages) on our outcomes can vary depending on whether we look at service or profit (or labour or output per worker). This is driven by the fact that a manager can compensate for changes in labour/productivity across tasks by changing unobserved effort.

4 Empirical analysis and main results

We look at how managers' input choices and performance respond to week 11 feedback by estimating the four linear equations (3) – (6) derived in our model. Recall that, going into the last two weeks before the actual tournament, week 11 feedback gives the manager two key pieces of information, for each performance measure (service, $i = 1$, and profit, $i = 2$). The first is the relative rank ($r_{i,t-1}$), and the second is proximity to the next bonus band border ($w_{i,t-1} = \{0, 1\}$), which captures the strength of financial incentives.

Hence, the four regressions we estimate take the following form:

$$y_{itmq} = \alpha_1 w_{1t-1qm} + \alpha_2 w_{2t-1qm} + \mu_1 r_{1t-1qm} + \mu_2 r_{2t-1qm} + \delta_{iq} + \xi_{im} + \epsilon_{itmq} \quad (7)$$

where m is a manager, q is a quarter, t is last two weeks of the quarter, and $t-1$ is week 11. Dependent variables, $y_{itmq} = \{\rho_{itmq}, \phi_{itmq}\}$, are as defined in our theoretical model; in other words, we have four different dependent variables: two outcomes (profit and service), and two inputs (labour and output per worker).

The equation reflects the finding of the model that each dependent variable may be a function of both profit-related week 11 variables (i.e. profit incentives and rank, w_{2t-1mq} and r_{2t-1mq}) and service-related week 11 variables (similarly, w_{1t-1mq} and r_{1t-1mq}). Recall that this is due to multitasking, and the fact that there is a trade off between inputs. Finally, δ_{iq} is an aggregate quarter effect and ξ_{im} is a manager fixed effect.

4.1 Data

Our data contain all of the stores in one country where the firm operates. On average this is 230 stores at any given time, growing over time from 180 to 290. In total, because of turnover, the data include 530 individual managers. It spans the six years, from 2010 to 2015 and the observations are quarterly. We use the first three quarters of each year in our analysis for the total of 18 quarters in the dataset[22].

We now describe the dependent variables in more detail.

- The firm measures **service** using mystery shoppers who come to each store weekly and fill out a score card. The total score on the card is the firm's, and our, measure of service.
- For **profit**, we use the measure used by the firm which excludes a number of costs that are outside a manager's control (such as the costs of ingredients and real estate). This means that the remaining key cost is labour, which is under the managers' control.[23]
- Labour is the total labour bill, i.e. sum of hours times wages paid.

[22] We exclude the fourth quarter because winter holidays create very particular quarter end patterns.

[23] For the purposes of the tournament, the firm goes one step further and uses profit deviations from a store specific target, calculated as a prediction from a regression which includes store characteristics, such as location, opening hours etc, in order to level the playing field in the tournament. Since these targets are revised very infrequently, and are outside manager control in the last two weeks of the quarter, we do not further adjust the profit in relation to them (as they would be absorbed by manager/store fixed effects in our regressions, see next section).

- Output per worker is the ratio of the value of the output produced by the store (i.e. food and drink prepared in the store, evaluated at their sales price) to total labour bill, regardless of whether the labour was used for production or service.

We observe these variables weekly. Each of these four dependent variables is defined as the average of the underlying measure in the last two weeks of the quarter (weeks 12 and 13), standardized by subtracting the mean and dividing by standard deviation. Their distributions, shown in Figure 2, have large outliers, for profit and labour at the top end, for service at the bottom end, and for output per worker at both ends[24]. Hence, we drop from our sample the observations that are in the top or bottom 0.5% of these distributions.

We now turn to independent variables:

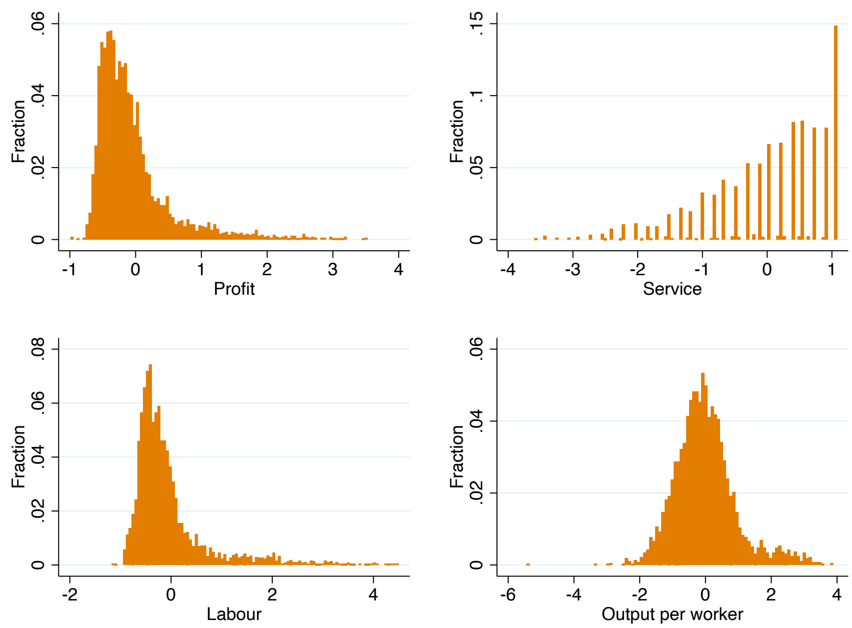
- For each performance measure i, profit and service, we observe manager m's rank on that measure for week 11 in quarter q, r_{it-1qm}. Each rank variable is coded so that it is increasing in performance and is normalized by the number of stores in the league table, so that it ranges from 1 (best) to 0 (worst).

- For each performance measure i, profit and service, the incentive dummy w_{it-1qm} is defined to be 1 if the manager m finds themselves within two ranks of the bonus band border in week 11 of quarter q (either above or below it) and 0 otherwise. On average, 38% of managers are near the border on profit and 62% of managers are near the border on service[25]. We run robustness checks with different definitions of w (see appendix G.3).

[24]Unsurprisingly, the service score distribution looks different from the rest because it is discrete and has a maximum value.

[25]Managers are more likely to be near the boder on service compared to profit because the former is measured on a discrete scale. This implies that, in service it is more likely than several shops receive the same rank and hence more shops find themselves close to the band border.

Figure 2: Distributions of manager performance and decisions in the last two weeks of the quarter



Notes: The variables are the average outcome in weeks 12 and 13, standarized by subtracting the mean and dividing by the standard deviation. Horizontal axis: standard deviations; vertical axis: fraction.

4.2 Identification

The key identifying variation is the fact that the strength of monetary incentives oscillates with absolute performance: it rises as the band border approaches and stays high as the border is crossed, then falls again until the next border (section 2.1). At the same time, the rank variable is a monotonic function of absolute performance. Thus, unlike many settings where marginal monetary incentives are often monotonic with rank, in our tournament incentives and rank do not always move together. Under mild assumptions on preferences (that the marginal value of changing rank is monotone), this variation allows us to identify rank concerns separately from monetary concerns.

Having separated the two effects, we now drill more into the requirements for unbiased identification of each of incentives and rank effects separately.

4.2.1 Incentives

The key identifying assumption for incentive effects is that a manager's proximity to the band border in week 11 is exogenous, conditional on the manager's performance. This seems likely for two reasons: first, it is hard to construct a plausible model where the manager, in earlier periods, would specifically target their position vis-a-vis the band border, over and above performance; second, the managers would find it hard to predict where exactly the border will be drawn because it depends on fluctuations in the performance of others and somewhat arbitrary decisions by the firm about how many managers to include in each band. Finally, even if such story could be constructed, as we note in section 4.3, our results are such that they are difficult to explain away by potential endogeneity.

4.2.2 Rank

A key concern in identifying the effects of performance-based rank at time $t-1$ on subsequent performance in t is potential serial correlation in performance across time. One source of such correlation is fixed manager or store characteristics (for example, manager ability or store location), which, unless controlled for, can lead to positive correlation between rank in week 11 and performance in the last two weeks. To this end, we include manager fixed effects in all regressions[26].

Although manager fixed effects go some way to reduce serial correlation, they may not eliminate all of it (as shown, in a similar context, by Gill et all 2019). For example, there may be positive correlation within the quarter across weeks if there are store specific quarterly shocks, or a negative correlation if there is reversion to the mean. In our dataset we find the evidence of the former: there is a strong positive time correlation between performance in weeks 12-13 of the quarter and that in the preceding weeks of the same quarter, arguably due store specific demand shocks, such as the opening of a competitor

[26]Since managers do not change stores very frequently, adding store fixed effects on top of manager fixed effects does not change our main results.

near-by or road works. We address this by controlling for the absolute level of the dependent variable at the end of week 11. Hence, in performance equations, the remaining variation in week 11 rank will be based on a given managers performance compared to the performance of other managers, and so any effects of rank on subsequent performance we identify are the effects of the manager's *relative* standing among her peers, controlling for the absolute level of her performance. In other words, our identifying assumption for the rank effects is that, given a manager's absolute performance in a given quarter, their rank is exogenous, as it is given by the performance of other managers[27].

4.3 Main Results

The results from estimating equations (3) through (6) from our model are reported in Table 2. We first look at manager performance in profit and service, and then at the their choices of the two inputs, labour and output per worker.

4.3.1 Outcomes

Columns (1) and (2) of Table 2 report the results of estimating equations (4) and (3). We first consider how monetary incentives affect each performance variable in turn. We find no significant impact of monetary incentives on profit (column (1)). However, facing high monetary incentives leads to a 0.1 standard deviation improvement in service, significant at the 5% level (column (2)). This is in line with standard economic theory and our model (i.e., *Observation 2*). The Profit+Service variable allows for the interaction of incentives in cases when a store is close to the border on both measures. As predicted by our model (i.e., *Observation 4*), this has the opposite sign of incentives on service. As we discuss in section 4.2, the key identifying assumption is that, *conditional on performance*, whether the manager happens to be close to the

[27]It is worth noting that, in our context, with very few exceptions, the shops are run completely independently of each other, and the manager of one shop has virtually no means of directly influencing performance of another shop. Hence, the exogeneity of rank is a plausible assumption in our context.

band boundary is not correlated with some underlying characteristic which would also affect the manager's performance in the last two weeks. We think this assumption is plausible since the exact location of the band border is chosen arbitrarily by the firm, depends on performance of other stores, and hence selection is virtually impossible. Furthermore, our results showing no or small incentive effects, together with the nuanced finding on the interaction term, make it hard to explain them away as driven by endogeneity.

Turning to rank, we find lower (worse) rank on profit leads to an improvement in profit, and the same is true for service (Columns (1) and (2), Rank section). These coefficients directly answer the two key questions laid out in the introduction.

First, as predicted by our theoretical model, we find significant coefficients on rank for both rank and profit. This mean that rank enters utility function (i.e. z_i cannot be zero for either performance measure). In other words, managers care about rank directly, and not just through monetary incentives. This is the key finding of our paper. Furthermore, we can compare the extents to which rank and financial incentives motivate performance improvements using service regressions: The average effect on performance of 1 extra rank is nearly ten times bigger than that of one extra dollar, in league tables containing roughly 80 managers on average [28].

Second, the negative sign of rank coefficients is consistent with *Observation 1*, and is diagnostic of a utility function that is concave in rank. An important implication of this is that receiving a worse rank motivates managers to work harder, rather than give up.

4.3.2 Inputs

Recall that a key advantage of our setting is that we observe labour and output per worker, two key inputs under the manager's control. Estimates for

[28] To calculate this, we use the following: the incentives coefficient of 0.1 captures the effect of crossing the border, which on average gives the manager $238 in bonus, while the rank coefficient of -0.3 captures the effect of moving from the last to the first rank in a league table with 83 ranks, on average.

Table 2: Rank and incentive effects

(Y = average in weeks 12-13)

	Profit (1)	Service (2)	Labour (3)	Output per worker (4)
Profit incentives	-0.01	0.07	-0.01	0.01
	(0.01)	(0.05)	(0.01)	(0.02)
Service incentives	-0.01	0.10**	-0.01	0.00
	(0.01)	(0.04)	(0.01)	(0.02)
Profit & Service incentives	0.01	-0.13**	0.01	0.03
	(0.01)	(0.07)	(0.01)	(0.03)
Profit rank	-0.04***	-0.03	-0.00	-0.15***
	(0.01)	(0.07)	(0.01)	(0.03)
Service rank	0.00	-0.30**	-0.03***	0.13***
	(0.01)	(0.12)	(0.01)	(0.03)
Incentives at the top	-0.01	0.04	-0.01	-0.00
	(0.01)	(0.06)	(0.01)	(0.03)
Standardized Y, weeks 1-11	0.90***	0.29***	0.96***	0.77***
	(0.01)	(0.07)	(0.01)	(0.02)
R^2	0.95	0.37	0.97	0.76
N	3,302	3,251	3,302	3,302

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: Dependent variable is the average in the last two weeks of each quarter, standardized. Regressions include manager and regional fixed effects. Output per worker is value of output produced over the total wage bill. 'Standardized Y, weeks 1-11' is the average of the dependent variable in weeks 1-11.

equations (5) and (6) which have inputs as dependent variables are reported in columns (3) and (4) of Table 2. These results can be read in a parallel way to the outcome results.

First, financial incentives do not have a significant effect on inputs. This is consistent with us not finding any effect of incentives on profit, though is a little surprising given we found incentive effects on service in column (2). This may be due to the fact that managers adjust unobserved inputs in response to monetary incentives.

Second, in line with *Observation 1* we find significant effects of rank (at the 1% level) on both labour and output per worker: managers increase labour when service ranking is low (column 3), and increase output per worker when profit rank is low (column 4). Hence these results are consistent with the managers using inputs to improve performance in profit and service when they find out their rank on that measure is low, as predicted by our model of managers with rank concerns.

Finally, in line with *Observation 4* we also observe a cross effect: managers reduce output per worker when service rank is low (column 3), consistent with re-allocating existing labour from production to service in order to improve the latter.

We find it important, and reassuring, that the key factors which the manager uses to control performance also show the response to rank consistent with our model, even though its predictions are nuanced due to the trade offs that these factors generate. In other words, the answers to the two key questions we pose in this paper are the same whether we look at manager performance or their input choices: managers care about rank and the relationship between utility and rank is concave.

4.3.3 Quantifying importance of rank

As an important, but ancillary, result we can leverage the structure of our model to compare the quantitative impact of money and rank on performance. We feel that although important, this result is secondary, as it relies on details of our model (e.g. the fully quadratic specification). Given these assumptions

Observation 3 allows us to calculate the strength of managers' preference for rank (on performance measure i) relative to money. We find that, in an average tournament, coming first instead of last in a service ranking is worth around \$1600 a year, or 17% of the bonus paid by the firm to its managers. Equivalently, for the largest, national, tournaments which include all managers in the country, this is worth \$4500 a year, or just under 50% of the bonus.

We now explain in detail how we arrive at these numbers. Recall that, in our model, the effect of rank on utility in monetary terms is denoted by $-z_i$, and that, to capture the context in our firm, we allow the effect to differ by performance measure, such that $i = 1$ is for service and $i = 2$ is for profit.

By observation 3 and the main regression equation (7),

$$-z_i = -\frac{\mu_i}{2\frac{\alpha_i}{\Delta}\beta_i} \tag{8}$$

where α_i is the empirically estimated effect of monetary incentives, i.e. the coefficient on the dummy variable w_i in regression equation (7), μ_i is the empirically estimated effect of rank in the same regression, Δ is the increase in bonus from crossing into the next band, and β_i is the impact of yesterday's rank on today's rank, as given by equation (1) in the model.

Hence, to estimate $-z_i$, we need

1. Rank and incentives coefficients from estimating regression equation (7), which are reported in Table 2, and
2. estimates of Δ and β_i which we can obtain from our data.

Let us first consider the impact of profit rank on utility, $-z_2$. From Table 2, we see that α_2, the impact of monetary incentives is not significantly different from zero. As equation (8) requires division by α_2, we cannot express the impact of profit rank on utility in monetary terms.

Luckily, for service we *can* obtain a measure of how much managers care about rank in monetary terms. From Table 2, $\alpha_1 = 0.1$, giving a change in service when the manager is close to the band border[29], and $\mu_1 = -0.3$, which

[29]For simplicity, we focus on the case where the manager is not close to both service and

measures how service responds when rank changes by 100%, i.e. the manager goes from being bottom to being top. This is for service league tables which have 83 managers, on average.

We now need to find β_1, how much final rank depends on interim rank. Recall that in the model we assume that this is given by

$$r_{1,t} = \rho_1 + \beta_1 r_{1,t-1} + \gamma_1$$

where $r_{1,t}$ and $r_{1,t-1}$ is service rank in t and $t-1$ respectively, ρ_1 are labour inputs in the later period t and γ_1 is a constant. We estimate this equation by regressing service rank in week 13 on service rank in week 11 and labour inputs in weeks 12 and 13[30]. This gives us $\beta_1 = 0.875$ (significantly different from zero at the 1% level).

Finally, the data also allow us to calculate Δ, the amount the manager can earn by crossing into the next service band in a given quarter. On average, $\Delta = \$238$.

Substituting these into equation (8), we find that $z_1 = \$396$. This is how much it is worth to a manager to be first rather than last in a quarterly service league table (with an average of 83 managers) – just over $1600 in annual terms. This is 17% of the bonus paid by the firm. This result also implies that in the quarters when tournaments are national, rather than regional, and there are 230 managers in the league table (on average), being first as opposed to last is worth just over $4500, or 48% of their performance bonus. To do this calculation for the largest tournament, we have to assume that the marginal rank effect we estimate does not change with the size of the league table. Given that we find virtually no non-linearities in the effects of rank (Appendix G), this assumption is reasonably consistent with our data.

---

profit boundary, i.e. the interaction term 'Profit & Service incentive' is 0, and so we can take α_1 alone as the measure of responsiveness to monetary incentives.

[30] We only do this for regional tournaments, which is the majority in our sample, since rank in week 11 is constructed assuming a regional tournament.

4.4 Robustness

In this section, we test whether our rank results may potentially be picking up more subtle financial incentives, rather than 'pure' status concerns. The two key cases are potential financial incentives generated by career concerns and by the multiplicative nature of the bonus scheme.

Career concerns

If the firm's retention and promotion decisions are related to a manager's rank, our results that managers respond to rank may be due to career concerns of the managers, rather than 'pure' status concerns.

To investigate this, we exploit additional data on promotions and departures of managers during 2008-2015. We ask whether profit and service rank are correlated with the probability of departing or being promoted in the firm[31], and report results in Table 4 in Appendix E.

First, we find that only one (out of the four) rank coefficients is significant, the one on profit rank in the promotion regression (column (3)). Second, once we include overall performance rank of the manager, which is a complicated function of ranks on individual performance measures, we find that it is the overall rank rather than ranks on individual measures that affects career prospects (columns (2) and (4)). Third, armed with this knowledge, we control for the manager's overall week 11 rank in our main regression (7), and find that our results are mostly unchanged (Table 5 in the Appendix E).

Hence, our key results, that managers try to improve performance when faced with lower rank on profit or service, are not due to managers acting on incentives created by career concerns.

Multiplicative incentives

As discussed in section 2.1, to calculate the managers' bonus, the firm multiplies the scores on the different performance measures. Consider the decision

[31] We do not have the data on managers being fired/asked to leave, and so we use departure as a proxy.

of a bonus maximizing manager on whether to improve profit or service in the run up to the tournament. Such manager will

(a) choose the measure on which he is close enough to the border to be able to cross into the next bonus band and so increase their score on that measure (first order monetary incentive discussed before).

(b) if they are close on both measures, choose the measure with the lower score (second order incentive due to the multiplicative nature of the scheme).

Note that the measure with the lower score is also likely to have the lower rank. Hence, in cases when (b) arises, our result that managers take steps to improve performance on the measure with a bad rank can potentially be explained by these subtle financial incentives rather than status concerns.

It turns out, however, that our data do not support this alternative explanation. There are three separate pieces of evidence:

1. Second order incentives are considerably more subtle and less obvious than the first order ones, and require a lot more sophistication from the managers to understand them. At the same time, we have seen earlier that the response to the more straightforward and salient first order incentives is not strong: we have found no response in profit and only a small response in service. This casts serious doubt on the relevance of multiplicative incentives in explaining that managers show strong responses to rank.

2. We used an incentivized survey to test the managers' understanding of multiplicative nature of the scheme, and found that at best only 30% understand it (see Appendix F). This is not entirely surprising: the incentives generated by multiplication are reasonably subtle, and to the best of our knowledge have not been emphasised or explained to the managers prior to our study. This is in contrast with, for example, incentives generated by being near a higher bonus band which is very visible in the managers' league tables, and are, therefore, very salient.

3. We test the multiplicative incentive explanation in a regression, by adding a dummy variable equal to 1 whenever the performance measure in y variable is the one with the lowest score (see Table 6 in Appendix F). Qualitatively, our results remain unchanged, whilst 'lowest score' variables are insignificant.

Hence it is hard to argue that the multiplicative incentives are behind the response to rank we observe.

We also conduct several other robustness checks, which keep only regional tournaments, use only wider bands, and experiment with changing the definition of incentives, i.e. how close to the band border the manager needs to be to face high incentives. Our results are largely unchanged (Appendix G). We also find little if any evidence of non-linear effects of rank (Appendix H).

5 Conclusions

We have analyzed how store managers who face a high stakes tournament incentive scheme react to regular feedback on two key performance measures, profit and service. We have shown that the managers try to improve their rank even when this will not bring obvious economic benefits. Furthermore, when rank concerns and marginal financial rewards call for different actions, people pay more attention to the former. The relationship between performance improvements and rank is monotonic and linear, suggesting that managers' utility is concave in rank. This is consistent, for example, with evolutionary models where, in the ancestral world, the actions of others contained signals about the environment, and so it was important to be not too far behind the pack (Samuelson 2004, Nöldeke and Samuelson 2005, Robson and Samuelson 2010)

Our first result, that when faced with a bad rank, people choose to catch up rather than to stop trying has clear implications for organizations. Note that the analysis is conditional on the decision of the manager to stay with the firm. This raises a further question of how ranking affects this (and selection more generally), which is an important topic for future work.

Our second finding, that rank concerns are more powerful than *marginal* financial incentives, also has strong implications for the design of incentive schemes in the workplace, and feedback schemes more generally. At the same time, they do not imply that financial rewards play no role. It is possible that monetary and non-monetary motivations interact in complex ways; this is an important direction for further research.

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Appendices

A Deriving the Regression Equations for the Enriched Model

Here we derive the equations related to service. The results related to profits are completely analogous.

Recall that the manager has three variables to maximize over ϕ_1 (which implicitly chooses ϕ_2), e_1 and e_2. This generates three first order conditions. The first, for ϕ_1, is:

$$\phi_1 = \frac{a_1 f^2 w_1 - a_2 f g w_2 - 2a_1 e_1 f^2 \psi_1 z_1 + 2a_1 f^2 k_1 z_1 - 2a_1 b_1 f^2 r_{1,t-1} z_1 + 2a_2^2 C g z_2 + 2a_2 e_2 f \psi_2 g z_2 - 2a_2 f g k_2 z_2 + 2a_2 b_2 f g r_{2,t-1} z_2}{2(a_1^2 f^2 z_1 + a_2^2 g^2 z_2)}$$

The second, for e_1, is:

$$e_1 = \frac{\psi_1 w_1 + 2\psi_1 k_1 z_1 - 2a_1 \psi_1 \phi_1 z_1 - 2b_1 \psi_1 r_{1,t-1} z_1}{2(h1 + \psi_1^2 z_1)}$$

The last, for e_2, is:

$$e_2 = \frac{f\psi_2 w_2 - 2a_2 C \psi_2 z_2 + 2f\psi_2 k_2 z_2 + 2a_2 \psi_2 g \phi_1 z_2 - 2b_2 f \psi_2 r_{2,t-1} z_2}{2f(h2 + \psi_2^2 z_2)}$$

We can then substitute the solutions for e_1 and e_2 into the equation for ϕ_i, and then solve out for ϕ_1:

$$\phi_1 = \frac{a_1 f^2 h1(w_1 + 2(k_1 - b_1 r_{1,t-1})z_1)(h2 + \psi_2^2 z_2) + a_2 g h2(h1 + \psi_1^2 z_1)(2a_2 C z_2 - f(w_2 + 2(k_2 - b_2 r_{2,t-1})z_2))}{2(a_2^2 g^2 h2(h1 + \psi_1^2 z_1)z_2 + a_1^2 f^2 h1 z_1 (h2 + \psi_2^2 z_2))}$$

After the appropriate substitutions, this equation is Equation (5).

To generate the equation for service, first we turn the first order condition with respect to e_1 into a function of service, by subtracting $\frac{(z_1 \psi_1 \psi_1 e_1)}{(h_1 + \psi_1^2 z_1)}$ from both sides:

$$\frac{\psi_1 w_1 + 2\psi_1 k_1 z_1 - 2\psi_1 z_1 \rho_1 - 2b_1 \psi_1 r_{1,t-1} z_1}{2(h_1 + \psi_1^2 z_1)} = e_1 - \frac{(2(z_1 \psi_1 \psi_1 e_1)}{2(h_1 + \psi_1^2 z_1))}$$

Through a sequence of (omitted) algebraic manipulations we can then solve for e_1, obtaining:

$$e_1 = \frac{\psi_1 w_1 + 2\psi_1 k_1 z_1 - 2b_1 \psi_1 r_{1,t-1} z_1 - 2\psi_1 \rho_1 z_1}{2h_1}$$

In a similar fashion we turn our equation for ϕ_1 into an equation for service via substitution:

$$\rho_1 = a_1 \frac{a_1 f^2 h1(w_1 + 2(k_1 - b_1 r_{1,t-1})z_1)(h2 + \psi_2^2 z_2) + a_2 g h2(h1 + \psi_1^2 z_1)(2a_2 C z_2 - f(w_2 + 2(k_2 - b_2 r_{2,t-1})z_2))}{2(a_2^2 g^2 h2(h1 + \psi_1^2 z_1) z_2 + a_1^2 f^2 h1 z_1 (h2 + \psi_2^2 z_2))} + \psi_1 e_1$$

Taking this last equation, we then use the penultimate equation to substitute out for e_1 and solve for ρ_1, giving:

$$\rho_1 = \frac{a_2^2 \psi_1^2 h^2 h2(w_1 + 2(k_1 - b_1 r_{1,t-1})z_1) z_2 + a_1^2 f^2 g1(w_1 + 2(k_1 - b_1 r_{1,t-1})z_1)(h2 + \psi_2^2 z_2) + a_1 a_2 g h1 h2(2a_2 C z_2 - f(w_2 + 2(k_2 - b_2 r_{2,t-1})z_2))}{2(a_2^2 g^2 h2(h1 + \psi_1^2 z_1) z_2 + a_1^2 f^2 h1 z_1 (h2 + \psi_2^2 z_2))}$$

After the appropriate substitutions, this equation is equivalent to Equation (3).

B Incentive scheme: score bands

Here we report more details on the score bands used in managers' bonuses. Typically, the ranking on each performance measure is divided into seven bands. The bands are drawn in such a way that top (highest) two bands have roughly 10% of stores in them, the next two bands have 30% and 20% respectively, and the bottom three bands have 10% of stores in each[32]. Inter alia, this implies that an average band has 14 stores in it.

The marginal benefit to manager j from jumping up one band on measure

[32] In practice, the bands can be slightly narrower or wider, to ensure that stores with the same absolute performance fall into the same band.

$m = i$ is given by

$$MB_{ijb} = \prod s_{b,m \neq i} \Delta s_{ijb} \tag{9}$$

where Δs_{ijb} is the jump in score that manager j faces on measure i. Depending on quarter and band, the jumps Δs_{ijb} can take on four values in our data: 5, 10, 15 and 20 points on the score scale, or 1.5-6 percentage points of the final bonus rate. The mode and median jump is 10 points or 3 percentage points of the bonus rate. Since the average bonus rate is 20% of base salary, jumping up one band on one measure gives a sizeable improvement in pay. Figure 1 illustrates a typical configuration of jumps: 10 points for all bands, except for one band in the middle, where the jump is 5 points.

C Band movements

The statement that incentives are stronger nearer the band border assumes that it is easier for people nearer the band border to cross it than for people who are further away. We check that this indeed is the case in our data in two ways. First, Table 3 shows that for both profit and service, the probability of managers crossing into the next band is statistically significantly higher if they are near the border. Second, Figure 3 confirms that it is not easy to move band during the last two weeks of the quarter: for both profit and service, nearly 60% of managers do not manage to move at all, and almost everyone who does move, only moves by one band.

D End of quarter dynamics

To get a feel for how the managers behave in the run up to the quarter end tournament, Figure 4 shows how the four outcome variables – profit, service, labour and output per worker – change in the last two weeks compared to the first eleven weeks of the quarter.

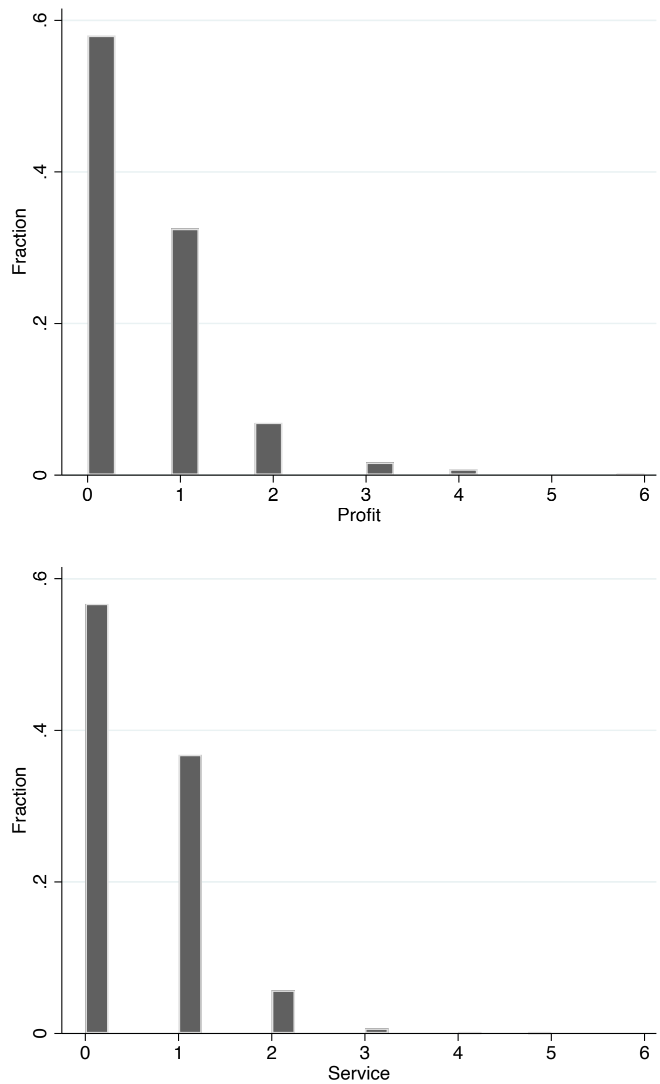
The mean and median change for all four outcomes are positive. This implies that as a group, managers improve both aspects of performance, profit

Table 3: Probability of crossing into the next band

	Profit	Service
	Next band up	
Near band border	0.32	0.41
	(0.02)	(0.02)
N	518	966
Further away	0.12	0.13
	(0.01)	(0.01)
N	2,130	2,266
	Next band down	
Near band border	0.29	0.24
	(0.02)	(0.01)
N	511	1,174
Further away	0.14	0.10
	(0.01)	(0.01)
N	2,137	2,058

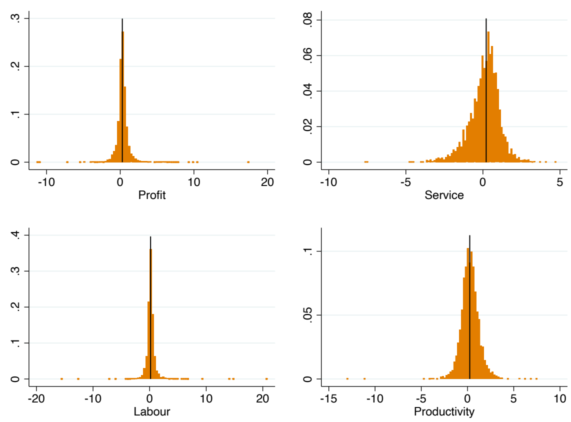
Note: Standard errors are in parentheses. The difference between 'Near' and 'Further away' is significant at 1% level in each pair.

Figure 3: Number of bands travelled in last two weeks



and service, as the tournament nears. The increase in labour and output per worker are consistent with the managers trying to improve both profit and service outcomes by hiring more labour, and potentially improving productivity, in line with our earlier finding in Table 2 columns (3) and (4).

Figure 4: Distribution of the change in the last two weeks of the quarter



Notes: The variables are the average outcome in weeks 12 and 13 minus the average outcome in weeks 1 to 11, divided by the standard deviation. Horizontal axis: standard deviations; Vertical axis: fraction. Black vertical line is the median.

E Career concerns

We start by asking whether career prospects at this firm are indeed linked to tournament ranks (Table 4). To do this, we use the sample of managers between 2008 and 2015, restricting in to those managers that stay with the firm for at least 18 months (about 5/6 of all managers).

We look at whether there is a relationship between profit and service ranks in a manager's early career and the probability of the manager leaving the firm before they spent 2.5 years there (columns 1 and 2) as well as the probability of being promoted to the next level (columns 3 and 4)[33,34].

We find that the only significant relationship is between profit rank and probability of promotion (Table 4, column (3)). The correlation with profit rank disappears when we control for the overall tournament rank, which has a significant positive relationship with promotion. Hence, although there is some evidence that managers who have a better rank do indeed face better prospects with the firm, unsurprisingly, the relationship is between overall rank rather than ranks on individual measures.

It is therefore possible that our main results on individual performance measures (Table 2) are in fact driven by the managers' desire to improve overall rank in response to career incentives at the firm. To check this, we re-estimate our original regressions now controlling for the overall rank that the manager receives in week 11 (Table 5). If this explanation is correct, the ranks on individual measures should no longer be significant. Instead, we find that our main results are virtually unchanged, either with respect to outcomes or inputs.

F Multiplicative incentives

In this section, we address the concern that the rank effects we have found can be explained away if the managers respond not only to the first order financial incentives, but also to the more subtle, second order, financial incentives generated by the multiplicative nature of the incentive scheme.

First, we note that this is doubtful since we find only very weak evidence that managers respond to first order financial incentives, which is a necessary condition for the second order incentive effects.

[33]We estimate a linear probability model. In columns 1 and 2 we look at whether ranks in the first 1.5 years are correlated with the probability of the manager staying on with the firm for 2.5 years or more; our results are the same if we use other cut offs. In our data, the average retention rate beyond 2.5 years for managers who have spent at least 1.5 years with the firm is 78%. This is an underestimate, because our data cannot distinguish between departure from the firm and a manager being promoted beyond the next level of the hierarchy.

[34]On average, 7% of managers get promoted to the next level.

Table 4: Rank and career prospects

	Probability of			
	Departure	Departure	Promotion	Promotion
	(1)	(2)	(3)	(4)
Service rank	-0.02	0.00	0.03	-0.09
	(0.10)	(0.11)	(0.08)	(0.09)
Profit rank	-0.13	-0.08	0.23	0.06
	(0.08)	(0.10)	(0.06)***	(0.08)
Overall rank		-0.10		0.32
		(0.12)		(0.10)***
Time at the firm			0.01	0.01
			(0.00)***	(0.00)***
Constant	0.29	0.31	-0.10	-0.12
	(0.06)***	(0.07)***	(0.05)**	(0.05)**
R^2	0.01	0.01	0.05	0.07
N	506	496	507	504

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes. Sample period is 2008-2015. Unit of observation is a manager. Sample is all managers who have served at least 1.5 years during the sample period. Columns (1) & (2): Dependent variable is 1 if the manager has left the firm during the sample period and 0 otherwise. Columns (3) & (4): Dependent variable is 1 if the manager was promoted during the sample period and 0 otherwise. Time at the firm is the total time the manager spent at the firm by the end of the sample period.

Table 5: Controlling for overall rank

(Y = average in weeks 12-13)

	Profit	Service	Labour	Output per worker
	(1)	(2)	(3)	(4)
Incentives				
Profit	-0.01	0.07	-0.01	0.01
	(0.01)	(0.05)	(0.01)	(0.02)
Service	-0.01	0.10	-0.01	0.00
	(0.01)	(0.04)**	(0.01)	(0.02)
Profit+Service	0.01	-0.13	0.01	0.03
	(0.01)	(0.07)**	(0.01)	(0.03)
Rank				
Profit	-0.05	-0.00	0.01	-0.20
	(0.02)***	(0.09)	(0.02)	(0.04)***
Service	-0.00	-0.28	-0.02	0.08
	(0.01)	(0.13)**	(0.02)	(0.04)**
Overall	0.01	-0.05	-0.03	0.09
	(0.02)	(0.11)	(0.02)	(0.05)*
R^2	0.95	0.37	0.97	0.76
N	3,302	3,251	3,302	3,302

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes. Dependent variable is the average in the last two weeks (12 & 13) of each quarter, standardized. Output per worker is value of output produced over the total wage bill. All rank and incentive variables are for week 11 of the quarter. Regressions include manager and regional fixed effects, controls for incentives at the top, average value of dependent variable in weeks 1-11 of the quarter, and proxy for size of the store.

Second, in a specially designed test, we find that most managers do not understand the second order incentives generated by the multiplicative nature of the bonus scheme.

Third, we construct a regression to test whether our rank results can be explained instead by multiplicative incentives, and we find that the answer to this is a 'no'.

Below, we elaborate on the second and third steps.

F.1 Incentivized test

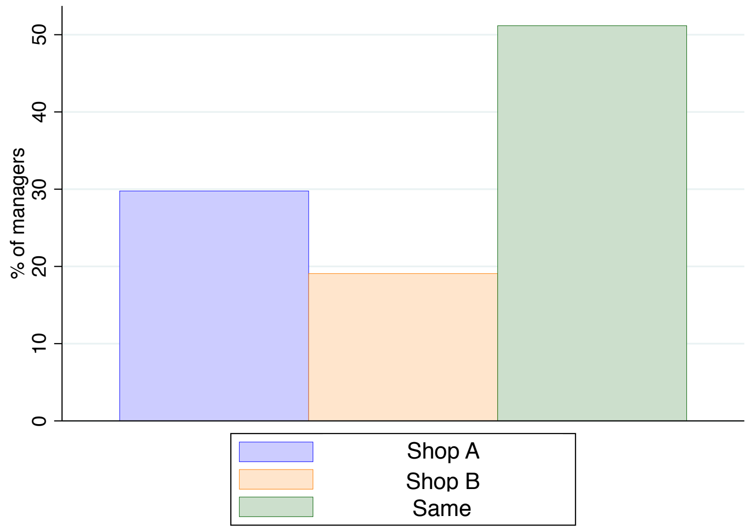
When we tested the managers understanding of the multiplicative nature of the scheme, we found that at best only 1/5 understand it. We asked the following question to 239 managers, paying for the right answer[35]:

> Consider two imaginary stores:
>
> **store A** falls into a 100% band in each of all four measures.
>
> **store B** falls into a **high** band on some measures, and a **low** band in others, but the **average** of these scores is 100%.
>
> Everything else that's relevant for the overall bonus in the tournament is the same for these two stores.
>
> Tick below which store has a higher overall bonus:
>
> (a) **store A.**
> (b) **store B.**
> (c) **Both will have the same overall bonus.**

The managers who correctly understand the incentives generated by the multiplicative nature of the scheme should choose (a). Figure 3 shows that only 30% of managers chose this answer. This is not entirely surprising: the incentives generated by multiplication are reasonably subtle, and to the best of

[35]This was part of a lab-in-the-field study described in more detail in Huffman, Raymond and Shvets 2021

Figure 5: Percent of managers choosing each answer



our knowledge have not been emphacised or explained to the managers prior to our study. This is in contrast with, for example, proximity to the next bonus band which is very visible in the managers' weekly feedback.

F.2 Estimation

Finally, we construct a regression to test whether our rank results can be explained instead by multiplicative incentives. If in previous estimations, for a given measure, we let proximity to the border proxy for incentives, we now add a dummy variable equal to 1 whenever this measure is the one with the lowest score[36]. If our results on importance of rank are instead due to the multiplicative financial incentives, we should see a positive coefficient on the lowest score dummies, whilst our rank variables should lose significance. It is a demanding test since the new variables take out a lot of potentially important variation: now rank effects can only be identified from relatively small movements in rank, i.e. only those that do not involve a measure changing

[36]This is across the three measure that the manager gets feedback on in week 11, profit, service and sales.

lowest score status.

The results in Table 6 show that, for improvements sales, profit and service, none of the incentive coefficients on the respective measure are significant (columns (1) and (2), rows 1 and 3). At the same time, respective rank effects remain significant on profit and service. For profit, it is now significant only at 10% level, and a bit lower in magnitude, whilst for service it remains significant at 5% and similar in magnitude to before. Moving from outcomes to labour decisions as our dependant variables, the results are qualitatively similar (columns (3) and (4)). This gives us confidence that the rank effects we observe are not driven by the multiplicative nature of the incentive scheme [37].

[37] We also run this estimation allowing for differences between the managers who understand multiplicative incentives and those who do not. We do not find any significant differences between them, and our results are largely unchanged. This is true for both regressions reported in Table 6 or in our main regressions in Table 2

Table 6: Controlling for lowest score measure

(Y = average in weeks 12-13)

	Profit	Service	Labour	Output per worker
	(1)	(2)	(3)	(4)
Incentives				
Profit	-0.00	-0.02	-0.00	0.02
	(0.01)	(0.03)	(0.01)	(0.02)
Service	-0.00	0.05	-0.00	0.01
	(0.01)	(0.03)	(0.01)	(0.02)
Lowest score				
Profit	0.01	-0.01	-0.01	0.04
	(0.01)	(0.04)	(0.01)	(0.02)**
Service	-0.01	0.02	-0.01	0.01
	(0.01)	(0.05)	(0.01)	(0.02)
Rank				
Profit	-0.03	-0.00	-0.00	-0.12
	(0.02)*	(0.09)	(0.02)	(0.04)***
Service	-0.01	-0.28	-0.03	0.11
	(0.02)	(0.13)**	(0.02)**	(0.04)***
Overall		-0.05		
		(0.11)		
R^2	0.95	0.37	0.97	0.76
N	3,302	3,251	3,302	3,302

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: Dependent variable is the average in the last two weeks of each quarter, standardized. Output per worker is value of output produced over the total wage bill. Regressions include manager and regional fixed effects, controls for incentives at the top, average value of dependent variable in weeks 1-11 of the quarter, and proxy for size of the store.

G Other robustness checks

G.1 Wider bands

Our definition of incentives, as proximity to band border, makes sense only if the bonus bands are wide enough. The average number of ranks in a band is 12 in our sample, with 6 and 7 as modes, but there is quite a bit of variation. So to make sure that our results hold if we restrict our attention to wide bands only, we re-run our main regressions restricting the sample to bands that are at least 7 ranks wide. Although our sample shrinks by over 1/3, Table 7 shows that our main results in Table 2 are qualitatively unchanged, which is reassuring.

Table 7: Wider bands

(Y = average in weeks 12-13)

	Profit	Service	Labour	Output per worker
	(1)	(2)	(3)	(4)
Incentives				
Profit	-0.02	-0.01	-0.02	-0.01
	(0.01)	(0.08)	(0.01)	(0.03)
Service	-0.00	0.16	-0.01	-0.00
	(0.01)	(0.05)***	(0.01)	(0.02)
Profit+Service	0.02	-0.08	0.02	0.04
	(0.02)	(0.10)	(0.02)	(0.04)
Rank				
Profit	-0.07	0.07	-0.01	-0.18
	(0.02)***	(0.11)	(0.02)	(0.05)***
Service	-0.01	-0.42	-0.05	0.15
	(0.02)	(0.18)**	(0.02)***	(0.04)***
R^2	0.96	0.46	0.97	0.81
N	1,795	1,768	1,795	1,795

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: Dependent variable is the average in the last two weeks of each quarter, standardized. Regressions include manager and regional fixed effects. Output per worker is value of output produced over the total wage bill.

G.2 Regional tournaments only

The firm runs two kinds of tournaments, regional and national. Although the rules are very similar, the latter is conducted nationally, with all the stores in the country competing, whilst for the former, the country is split into 2-4 regions, with a separate tournament in each. Initially all tournaments had been regional, but from quarter four of 2011 they alternate between regional and national. This means that in our sample, all but four tournaments are regional.

For historical reasons, the software generating the league tables for weekly feedback assumes that the tournament is regional. So, the feedback is a noisier predictor of what happens in the actual tournament in the quarters when the latter is national. Still, week 11 rank continues to be strongly correlated with the final tournament rank even then (Spearman coefficient of 0.8, see Figure 6).

However, the information about incentives is probably lost: proximity to the border in a regional league table does not imply the same for a national one. Hence, we check robustness of our estimates by dropping the four national tournaments. The results, summarized in Table 8, are virtually unchanged by this.

Figure 6: Feedback (week 11) rank is a good predictor of actual tournament rank

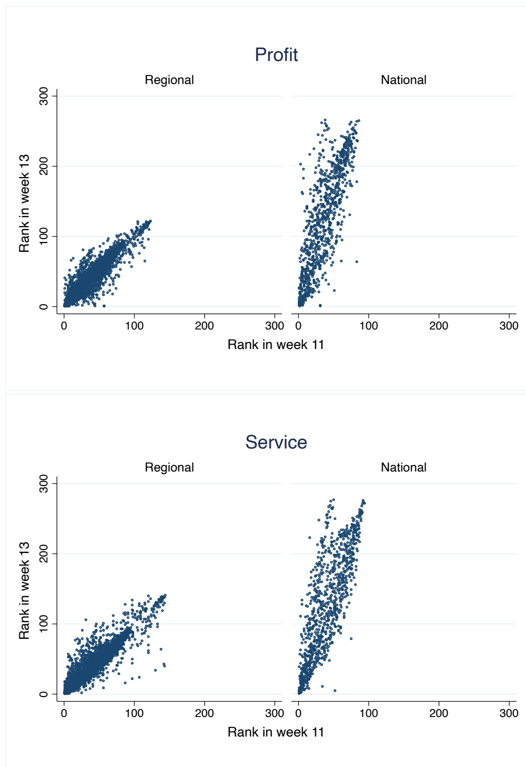


Table 8: Regional tournaments only

(Y = average in weeks 12-13)

	Profit	Service	Labour	Output per worker
	(1)	(2)	(3)	(4)
Incentives				
Profit	-0.02	-0.01	-0.02	0.01
	(0.01)	(0.07)	(0.01)	(0.03)
Service	-0.01	0.07	-0.00	-0.00
	(0.01)	(0.05)	(0.01)	(0.02)
Profit+Service	0.02	-0.04	0.01	0.02
	(0.01)	(0.08)	(0.01)	(0.04)
Rank				
Profit	-0.06	0.02	-0.01	-0.15
	(0.02)***	(0.08)	(0.01)	(0.04)***
Service	0.01	-0.21	-0.02	0.12
	(0.01)	(0.14)	(0.01)**	(0.03)***
R^2	0.95	0.41	0.98	0.78
N	2,443	2,431	2,443	2,443

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: Dependent variable is the average in the last two weeks of each quarter, standardized. Output per worker is value of output produced over the total wage bill. Regressions include manager and regional fixed effects, controls for incentives at the top, average value of dependent variable in weeks 1-11 of the quarter, and proxy for size of the store.

G.3 Alternative definition of incentives

While the theory of tournaments tells us that managers close to the boundary of the bonus band will face steeper incentives, it does not give us much of a guide for how close is close enough. So far, we have defined a manager as facing steeper incentives if he is in a two rank window on either side of the boundary. To check whether our results are robust to alternative definitions, we re-run the estimations with windows of 1 rank (9) and 3 ranks (not reported). Our results on rank variables are unchanged, though the incentive effects on service are no longer significant.

Table 9: Alternative incentive definition

(Y = average in weeks 12-13)

	Profit	Service	Labour	Output per worker
	(1)	(2)	(3)	(4)
Incentives				
Profit	-0.00	0.00	-0.01	0.03
	(0.01)	(0.05)	(0.01)	(0.02)
Service	-0.01	0.01	-0.01	0.02
	(0.01)	(0.04)	(0.01)	(0.02)
Profit+Service	0.00	-0.04	0.00	0.01
	(0.01)	(0.08)	(0.02)	(0.04)
Rank				
Profit	-0.04	-0.03	-0.00	-0.15
	(0.01)***	(0.07)	(0.01)	(0.03)***
Service	0.00	-0.32	-0.03	0.12
	(0.01)	(0.12)***	(0.01)***	(0.03)***
R^2	0.95	0.37	0.97	0.76
N	3,302	3,251	3,302	3,302

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: Dependent variable is the average in the last two weeks of each quarter, standardized. Output per worker is value of output produced over the total wage bill. Regressions include manager and regional fixed effects, controls for incentives at the top, average value of dependent variable in weeks 1-11 of the quarter, and proxy for size of the store.

H Non-linear effects

In our regressions, we have assumed that rank has a linear effect on variables of interest. But it is possible that these effects are non-linear and even non-monotonic (as in Gill et al (2019)). Do managers at the top display particular complacency, or instead might they work harder encouraged by their top position? Conversely, do managers at the bottom get discouraged and drop out or do they work harder still to avoid being last?

To explore these questions, we re-estimate our main equation (7) adding dummy variables for whether a manager was in top 5% or bottom 5% of the rank on each of the tournament measures, profit and service, and on inputs, labour and output per worker.

The results in Table 10 shows that our main conclusion still holds: linear rank variable has similar effects on the variables of interest as before, in Table 2. However, alongside these we now see added complacency at the top in profit measure (column (1)), an added dislike of being at the bottom in the service measure (column (2)) and an added desire to cut labour when at the bottom of profit rank (column (3)).

So although these results are not the same across different measures, together they allow us to say three things. First, the effect of rank is monotonic: in all specifications the desire to improve always increases as the rank gets worse. Second, this is not driven purely by the bottom ranks. Third, what evidence of non-linearity there is points at particular complacency at the top and dislike of bottom ranks.

Table 10: Non-linear rank effects

(Y = average in weeks 12-13)

	Profit	Service	Labour	Output per worker
	(1)	(2)	(3)	(4)
Profit				
Rank	-0.04	-0.02	-0.01	-0.13
	(0.01)***	(0.08)	(0.01)	(0.04)***
Top 5%	-0.01	-0.13	0.01	-0.08
	(0.02)	(0.09)	(0.02)	(0.04)**
Bottom 5%	0.00	-0.03	-0.02	0.00
	(0.01)	(0.08)	(0.01)	(0.04)
Service				
Rank	0.00	-0.34	-0.02	0.12
	(0.01)	(0.12)***	(0.01)	(0.03)***
Top 5%	0.01	-0.05	-0.00	0.01
	(0.01)	(0.08)	(0.01)	(0.04)
Bottom 5%	0.01	0.16	0.03	-0.01
	(0.01)	(0.08)*	(0.01)**	(0.04)
R^2	0.95	0.37	0.97	0.76
N	3,302	3,251	3,302	3,302

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Notes: Dependent variable is the average in the last two weeks of each quarter, standardized. Output per worker is value of output produced over the total wage bill. Regressions include manager and regional fixed effects, controls for incentives at the top, average value of dependent variable in weeks 1-11 of the quarter, and proxy for size of the store.

I Equilibrium Model

In the body of the paper we consider the problem from the perspective of a single decision-maker, as opposed to the equilibrium outcome of a game. Although, as discussed, this may be a reasonable approximation in many situations, it also raises the question to what extent the results generalize into a full equilibrium setup.

Our setting has several interesting features that make it different than many of the models of contests considered in the literature. First, it is a contest where there are multiple, heterogeneous, prizes (i.e. the value of any particular ranking as well as any monetary benefits). Second, it is a contest where in the last period individuals vary in their initial advantage, due to potential differences in past performance. Third, it is a contest where there are more than two players (and in fact many players, on the order of hundreds).

There are extant papers that explicitly consider multi-period dynamic contests (e.g., Yildirim, 2005), but they focus on situations with two players and a single prize. There is also a literature that explicitly models contests for status (e.g., Moldovanu et al., 2007) but they do explicitly allow for head starts. Rather, they model heterogeneity by changing the marginal cost of provision of effort. On the other hand, there is a small literature that thinks about contests with head starts (e.g., Siegel, 2014) with more than two players and more than a single prize, but they do not allow for the prizes to be heterogeneous. Existing results regarding large contests, i.e., Olszewski and Siegel (2016), unfortunately, do not apply to our setting.

Thus, in order to derive simple intuitions regarding what should happen in our setting, we will consider a simple environment with a continuum of agents, which approximates our setting with many managers. In order to keep the discussion simple, we will focus only on discussing "inputs" in the final period (rather than also considering outputs). In the simple model we develop below, inputs in any given period are equivalent to outputs. We will also, for the sake of simplicity, focus first on the situation where we can consider each of the two tasks separately (i.e. they are additively separable), and then focus on a representative task. Thus, we set aside interaction concerns between the two tasks which our enriched model in the body of the paper considered. Then, we extend our framework to incorporate these interactions. Unlike in the body of the paper, where returns to rank were assumed to be concave, here we assume that they are linear. We also suppose that there is no noise in the production process — agents can perfectly choose their output level.

We will use the simple framework to show that our first and second observations hold in this setting. Subsequently, we use the extended environment to account for the fourth observation. As we discuss, although some modified version of the third observation would hold, it would look different depending on the exact parametrization of the environment.

I.1 Simple Model

Formally, we will assume that there are a continuum of agents, indexed by a type $\theta \in (0, 1)$. We think of this type as the agents' performance at the beginning of the period. There is a distribution F over θ, and so F gives the rank of θ.

Each agent chooses an effort level b. We can think of this as choosing the input level. For simplicity, we will simply think of each type θ choosing an effort level $b(\theta)$. The cost of effort is $\gamma\frac{b(\theta)^2}{2}$. Performance at the end of the period is then $\theta + b(\theta)$. We denote the distribution over $\theta + b(\theta)$ as G. Thus, G gives the rank of the individual at the end of the period.

We will suppose that f is non-atomic and continuous. Moreover, we will maintain the assumption that $\gamma > f'(x) > -\gamma$ for all x. This assumption guarantees that the equilibrium can be solved for using the first order conditions, and that individuals with higher initial ranks end up with higher final ranks.

First, let's focus on the situation where the individual only cares about their rank (there are no monetary bonuses). The utility of a given individual is then

$$G(\theta + b(\theta)) - \gamma \frac{b(\theta)^2}{2}$$

The next proposition formalizes the equilibrium under this assumption.

Proposition E1: *There exists an equilibrium where agents of type θ choose $b(\theta) = \frac{f(\theta)}{\gamma}$, and $\theta + b(\theta)$ is strictly increasing in θ.*

Proof of Proposition E1: Any given agent of type θ (fixing the action $b(\theta)$ of all other agents) wants to maximize, by their choice of b, the following function: $G(\theta + b) - \gamma \frac{b^2}{2}$. The first order condition is then $g(\theta + b) - \gamma b = 0$. The second order condition is $g'(\theta + b) - \gamma < 0$.

Notice that given our conjectured equilibrium, $G(\theta + b(\theta)) = \text{Prob}(\theta + b(\theta) \geq x + b(x)) = \text{Prob}(\theta \geq x) = F(\theta)$. Thus, for our agent $G(x + b(x)) = F(x)$. Therefore, by our assumptions on F, the second order condition is satisfied. Thus, the solution to b must solve $b = \frac{g(\theta+b)}{\gamma}$. Given that all other agents are playing $b(\theta) = \frac{f(\theta)}{\gamma}$, it's the case that $b = \frac{f(\theta)}{\gamma}$ solves the equation $b = \frac{g(\theta+b)}{\gamma}$.

We used the fact that $\theta + b(\theta)$ is strictly increasing in θ in our construction. We now must verify that in fact it is true in our proposed equilibrium. Thus, we want it to be true that $\theta_1 + b(\theta_1) \geq \theta_2 + b(\theta_2)$ if and only if $\theta_1 \geq \theta_2$. Given our equilibrium this is equivalent to $\theta_1 + \frac{f(\theta_1)}{\gamma} \geq \theta_2 + \frac{f(\theta_2)}{\gamma}$ if and only if $\theta_1 \geq \theta_2$. We can rewrite this as $\frac{1}{\gamma}[f(\theta_1) - f(\theta_2)] \geq \theta_2 - \theta_1$ if and only if $\theta_1 \geq \theta_2$. Without loss suppose $\theta_1 \geq \theta_2$. Then we can rewrite the first inequality as $\frac{f(\theta_1)-f(\theta_2)}{\theta_2-\theta_1} \leq \gamma$, or, $\frac{f(\theta_1)-f(\theta_2)}{\theta_1-\theta_2} \geq -\gamma$. Notice that a necessary and sufficient condition for this to be true for any θ_1 and θ_2 is that $f' \geq -\gamma$, which is assumed. $\square$

We next turn to allowing for, in addition to rank concerns, a monetary bonus. In order to keep things simple we will start assuming that there is a single threshold, above which the individuals earn an additional monetary bonus. The equilibrium construction generalizes to additional thresholds, but requires additional notation, which we will provide in the next section.

In particular, we suppose that there is a scalar $R \in [0, 1]$ such that for any individual i with final performance x, if $G(x) \geq R$, then x earns m dollars (otherwise they earn 0 dollars). We denote the weight on the concern for rank as α. Thus, the individual seeks to maximize the following utility function

$$\alpha G(\theta + b(\theta)) + m\mathbb{1}\{G(\theta + b(\theta)) \geq R\} - \gamma\frac{b(\theta)^2}{2}$$

For individuals who would naturally already choose a b that would place them above the threshold R, nothing changes relative to the prior set-up. Similarly, if an individual would be very far away from the threshold R for any reasonable amount of effort, then their problem is the same as the prior set-up (as is their solution). But for individuals whose final rank would be close enough to R under the prior setup face a new trade-off. If they exert a bit more effort, to get their rank up to R, they get a fixed bonus. Thus, we will observe a mass of individuals who will work just hard enough to ensure that they get the bonus.

We denote $\bar{\theta} = F^{-1}(R)$, and let $\underline{\theta}$ (which we call the "threshold type") be the solution to

$$\alpha F(\underline{\theta}) - \gamma\frac{\frac{\alpha^2 f(\underline{\theta})^2}{\gamma^2}}{2} = \alpha F(\bar{\theta}) + m - \gamma\frac{(\bar{\theta} - \underline{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma})^2}{2}$$

Observe that there exists some $0 \leq \underline{\theta} < \bar{\theta}$ that satisfies this definition, under some regularity assumptions on f. For any type $\bar{\theta} - \epsilon$, as ϵ goes to 0, the difference between the RHS and the LHS goes approximately to m, so there must exist a type that prefers to exert a small additional effort (at negligible cost) to gain m. We modify the assumptions for Proposition E1 slightly: $\frac{\gamma}{\alpha} > f'(x) > -\frac{\gamma}{\alpha}$

The next proposition formalizes these intuitions.

Proposition E2: *There exists an equilibrium where*

- *if* $\theta > \bar{\theta}$ *then* $b(\theta) = \frac{\alpha f(\theta)}{\gamma}$, *and* $\theta + b(\theta)$ *is strictly increasing in* θ
- *if* $\theta \in [\underline{\theta}, \bar{\theta}]$ *then* $b(\theta) = \bar{\theta} - \theta + \frac{\alpha f(\bar{\theta})}{\gamma}$ *and* $\theta + b(\theta)$ *is constant in* θ
- *if* $\theta < \underline{\theta}$ *then* $b(\theta) = \frac{\alpha f(\theta)}{\gamma}$, *and* $\theta + b(\theta)$ *is strictly increasing in* θ

Proof of Proposition E2: Begin with agents where $F(\theta) \geq R$. In this, given the behavior of others, their optimization problem is exactly the same as it was in the setting for Proposition E1. Thus, their solution is the same.

Now consider an agent of type $\underline{\theta}$. Choosing any $b < \frac{\alpha f(\underline{\theta})}{\gamma}$ is suboptimal (since $b = \frac{\alpha f(\underline{\theta})}{\gamma}$ delivers a higher payoff). Similarly, choosing any $b > \bar{\theta} - \underline{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma}$ is suboptimal, because the marginal cost of additional b exceeds the benefit. Last, for $\underline{\theta}$ to choose anything strictly between $\frac{\alpha f(\underline{\theta})}{\gamma}$ and $\bar{\theta} - \underline{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma}$ is strictly dominated, because the rank does not change. The utility from choosing $b = \frac{\alpha f(\underline{\theta})}{\gamma}$ is

$$\alpha F(\underline{\theta}) - \gamma \frac{\frac{\alpha^2 f(\underline{\theta})^2}{\gamma^2}}{2}$$

while the utility from choosing $b = \bar{\theta} - \underline{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma}$ is

$$\alpha F(\bar{\theta}) + m - \gamma \frac{(\bar{\theta} - \underline{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma})^2}{2}$$

By construction, these payoffs are equal.

Consider any individual with $\tilde{\theta}$ such that $\underline{\theta} < \tilde{\theta} < \bar{\theta}$. By the same reasoning as before, choosing any $b \notin \{\underline{\theta} - \tilde{\theta} + \frac{\alpha f(\underline{\theta})}{\gamma}, \bar{\theta} - \tilde{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma}\}$ cannot be optimal. If b is the former, then the payoff is

$$\alpha F(\underline{\theta}) - \gamma \frac{(\underline{\theta} - \tilde{\theta} + \frac{\alpha f(\underline{\theta})}{\gamma})^2}{2},$$

and the payoff for the other alternative is

$$\alpha F(\bar{\theta}) + m - \gamma \frac{(\bar{\theta} - \tilde{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma})^2}{2}.$$

Relative to the payoff option for the $\underline{\theta}$ type, notice that inside the quadratic term of the cost function, the $\tilde{\theta}$ type has a term $\underline{\theta} - \tilde{\theta} < 0$. Because of the convexity of the cost function, this implies a large cost decrease for the initially higher cost, which is attached to the higher b. This implies that the $\tilde{\theta}$ individual strictly prefers to set $b = \bar{\theta} - \tilde{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma}$. Thus, any type between $\underline{\theta}$ and $\bar{\theta}$ prefers to set $b = \bar{\theta} - \tilde{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma}$.

Consider any type $\theta < \underline{\theta}$. Observe that if this type weakly preferred to set $b = \bar{\theta} - \theta + \frac{\alpha f(\bar{\theta})}{\gamma}$ to any other b, then we could simply replicate the argument for $\tilde{\theta}$ but now using $\underline{\theta}$ and show that $\underline{\theta}$ should strictly prefer to set b at $\bar{\theta} - \underline{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma}$. This would be a contradiction. Thus, all types below $\underline{\theta}$ will not choose any b that would allow them to get the bonus. Thus they face they same incentives as they did when solving out Proposition E1, and the same solution. $\square$

Consider our first two observations in the body of the paper. Notice that so long as f is falling in θ, then $b(\theta)$ is falling in θ. Thus the necessary and sufficient condition for b to fall with initial rank is that f is decreasing in initial rank.

Second, index the threshold types by m. Consider m_1, m_2 such that $m_1 < m_2$. Observe that the $\underline{\theta}(m_1)$ strictly prefers to exert the effort to get the monetary bonus at m_2. Because we've already established that the equilibrium is threshold, this implies that the threshold type must have fallen. Thus, fixing R, as m increases, $\underline{\theta}$ falls. This means that the average distance between $\bar{\theta}$ and all types who pool with $\bar{\theta}$ must increase, implying that the average effort must increase for the individuals who can earn the bonus.

Observation 3 has no simple analogue in this setting. The threshold type is a relatively complicated (an implicitly defined) function of the parameters (including m and α). This implies that the average effort of agents who are willing to exert more effort to earn the bonus (i.e. those between $\underline{\theta}$ and $\bar{\theta}$) will depend on the distribution f in a non-trivial way. Thus the relationship between the effect of status on b and money on b will be a function of α (i.e. the relative value of money and rank) but not necessarily in the simple way discussed in the body of the paper.

For example, suppose f is uniform. We make this assumption in order to consider the simplest case for understanding the threshold type. Observe, however, that this implies that b is constant in θ when $\theta > \bar{\theta}$ or $\theta < \underline{\theta}$. In this case Proposition E2 says

- if $\theta > \bar{\theta}$ then $b(\theta) = \frac{\alpha}{\gamma}$
- if $\theta \in [\underline{\theta}, \bar{\theta}]$ then $b(\theta) = \bar{\theta} - \theta + \frac{\alpha}{\gamma}$

- if $\theta < \underline{\theta}$ then $b(\theta) = \frac{\alpha}{\gamma}$

Let $\hat{\theta} = \bar{\theta} - \underline{\theta}$. The threshold type then solves the equation

$$2\left(\alpha\hat{\theta} + m\right) = \gamma\hat{\theta}^2 + 2\hat{\theta}$$

Since we know that $\hat{\theta}$ is positive, the solution is then

$$\hat{\theta} = \frac{2(\alpha-1) + \sqrt{4(\alpha-1)^2 + 8\gamma m}}{2\gamma}$$

or in other words

$$\underline{\theta} = \bar{\theta} - \frac{(\alpha-1) + \sqrt{(\alpha-1)^2 + 2\gamma m}}{\gamma}$$

Thus, the effects of the monetary bonus are non-linear on the threshold, and so on the average effort amongst those who are influenced by the threshold:

$$\frac{\int_{\bar{\theta}-\frac{(\alpha-1)+\sqrt{(\alpha-1)^2+2\gamma m}}{\gamma}}^{\bar{\theta}} b(x)f(x)dx}{\int_{\bar{\theta}-\frac{(\alpha-1)+\sqrt{(\alpha-1)^2+2\gamma m}}{\gamma}}^{\bar{\theta}} f(x)dx} = \frac{\int_{\bar{\theta}-\frac{(\alpha-1)+\sqrt{(\alpha-1)^2+2\gamma m}}{\gamma}}^{\bar{\theta}} \left[\bar{\theta} - x + \frac{\alpha}{\gamma}\right] f(x)dx}{\int_{\bar{\theta}-\frac{(\alpha-1)+\sqrt{(\alpha-1)^2+2\gamma m}}{\gamma}}^{\bar{\theta}} f(x)dx}$$

or in other words

$$\frac{\bar{\theta}^2 - \frac{1}{2}\bar{\theta}^2 + \frac{\alpha\bar{\theta}}{\gamma} - \bar{\theta}\left(\bar{\theta} - \frac{(\alpha-1)+\sqrt{(\alpha-1)^2+2\gamma m}}{\gamma}\right) + \frac{1}{2}\left(\bar{\theta} - \frac{(\alpha-1)+\sqrt{(\alpha-1)^2+2\gamma m}}{\gamma}\right)^2 - \frac{\alpha}{\gamma}\left(\bar{\theta} - \frac{(\alpha-1)+\sqrt{(\alpha-1)^2+2\gamma m}}{\gamma}\right)}{\frac{(\alpha-1)+\sqrt{(\alpha-1)^2+2\gamma m}}{\gamma}}$$

Simplifying this gives

$$\frac{\alpha}{\gamma} + \frac{(\alpha-1) + \sqrt{(\alpha-1)^2 + 2\gamma m}}{2\gamma}$$

Recall that in the simple one-person decision problem modelled in the body of the paper, we had the ratio of two numbers. In the numerator was the coefficient of individuals who had only rank concerns. In the denominator was the sum of coefficients of individuals who had both rank and monetary concerns, minus the coefficient of individuals who had solely rank concerns.

In the equilibrium setting, the equivalent numerator is $\frac{\alpha}{\gamma}$, while the equivalent denominator is $\frac{(\alpha-1)+\sqrt{(\alpha-1)^2+2\gamma m}}{2\gamma}$. Thus the ratio becomes $\frac{2\alpha}{(\alpha-1)+\sqrt{(\alpha-1)^2+2\gamma m}}$. Notice that this depends on the relative size of the concern about rank α relative to the monetary bonus m, but in a more complicated way than in the simpler model in the body of the paper.

In the next two subsections, we will extend the model to allow for multiple thresholds and multiple tasks. Allowing for multiple tasks will enable us to replicate the results of Observation 4.

I.2 Multiple thresholds case

Now assume that instead of having a single monetary bonus associated with a single threshold, there are multiple monetary bonuses, each one associated with a particular threshold. Formally, assume there are $K \in \mathbb{N}_{\geq 2}$ thresholds such that $R_k \in (0,1)$ for all $k \in \{1, \cdots, K\}$ and $R_k < R_{k+1}$ for all $k \in \{1, \cdots, K-1\}$. Also assume there are K monetary bonuses such that $0 < m_1 < \cdots < m_K$. Denote $\overline{\theta}_k = F^{-1}(R_k)$ for all $k \in \{1, \cdots, K\}$.

The individual seeks to maximize the following utility function

$$\alpha G(\theta+b(\theta))+\sum_{k=1}^{K-1} m_k \mathbb{1}\{R_k \leq G(\theta+b(\theta) \leq R_{k+1}\}+m_K \mathbb{1}\{G(\theta+b(\theta) \geq R_K\}-\gamma\frac{b(\theta)^2}{2}$$

Let $\underline{\theta}_k$ (which we call the "threshold types") be the solution to

$$\alpha F(\underline{\theta}_1) - \frac{\gamma}{2}\left(\frac{\alpha f(\underline{\theta}_1)}{\gamma}\right)^2 = \alpha F(\overline{\theta}_1) + m_1 - \frac{\gamma}{2}\left(\overline{\theta}_1 - \underline{\theta}_1 + \frac{\alpha f(\overline{\theta}_1)}{\gamma}\right)^2, \text{ if } k = 1$$

$$\alpha F(\underline{\theta}_k) + m_{k-1} - \frac{\gamma}{2}\left(\frac{\alpha f(\underline{\theta}_k)}{\gamma}\right)^2 = \alpha F(\overline{\theta}_k) + m_k - \frac{\gamma}{2}\left(\overline{\theta}_k - \underline{\theta}_k + \frac{\alpha f(\overline{\theta}_k)}{\gamma}\right)^2, \text{ if } k \in \{2, \cdots, K\}$$

Under some regularity assumptions on f, there exists some $0 \leq \underline{\theta}_k < \bar{\theta}_k$ that satisfies this definition for all k. Additionally, we assume that the monetary bonuses are such that the inequality $\overline{\theta}_k < \underline{\theta}_{k+1}$ holds for all $k \in \{1, \cdots, K-1\}$. Under some conditions, we will have an equilibrium that is similar to the simple case and where the individuals do not have an incentive to exert more effort to jump to higher order thresholds. The next proposition formalizes this idea.

Proposition E3: *There exists an equilibrium where*

- *if* $\theta \in \left(\bar{\theta}_k, \underline{\theta}_{k+1}\right)$ *then* $b(\theta) = \frac{\alpha f(\theta)}{\gamma}$, *and* $\theta + b(\theta)$ *is strictly increasing in* θ for all $k \in \{1, \cdots, K-1\}$
- *if* $\theta \in \left[\underline{\theta}_k, \bar{\theta}_k\right]$ *then* $b(\theta) = \bar{\theta}_k - \theta + \frac{\alpha f(\bar{\theta})}{\gamma}$ *and* $\theta + b(\theta)$ *is constant in* θ for all $k \in \{1, \cdots, K\}$
- *if* $\theta \in [0, \underline{\theta}_1)$ *then* $b(\theta) = \frac{\alpha f(\theta)}{\gamma}$, *and* $\theta + b(\theta)$ *is strictly increasing in* θ
- *if* $\theta \in \left(\bar{\theta}_K, 1\right]$ *then* $b(\theta) = \frac{\alpha f(\theta)}{\gamma}$, *and* $\theta + b(\theta)$ *is strictly increasing in* θ

Proof of Proposition E3: Begin with agents where $F(\theta) > R_K$, i.e., $\theta \in \left(\bar{\theta}_K, 1\right]$. For these types, given the behavior of others, their optimization problem has a setting analogous to the one in Proposition E1. Thus, their solution is also given by the first order condition, assuming that in equilibrium $G(\theta + b(\theta)) = F(\theta)$.

Now fix $k \in \{1, \cdots, K\}$ and consider an agent of type $\overline{\theta}_k$. Choosing any $b < \frac{\alpha f(\underline{\theta}_k)}{\gamma}$ is suboptimal (since $b = \frac{\alpha f(\underline{\theta}_k)}{\gamma}$ delivers a higher payoff). Similarly, choosing any $b > \bar{\theta}_k - \underline{\theta}_k + \frac{\alpha f(\bar{\theta}_k)}{\gamma}$ is suboptimal if the following inequality holds for every $j > k$:

$$m_j - m_k < \frac{\gamma}{2}\left(\left(\bar{\theta}_j - \underline{\theta}_k\right)^2 - \left(\bar{\theta}_k - \underline{\theta}_k\right)^2 + \frac{\alpha^2\left(f(\bar{\theta}_j)^2 - f(\bar{\theta}_k)^2\right)}{\gamma^2}\right) - \alpha\left(F(\bar{\theta}_j) - F(\bar{\theta}_k)\right)$$
$$+ \alpha\left(f(\bar{\theta}_j)\left(\bar{\theta}_j - \underline{\theta}_k\right) - f(\bar{\theta}_k)\left(\bar{\theta}_k - \underline{\theta}_k\right)\right)$$

This is because the marginal cost of additional b exceeds the benefit. Notice that this inequality guarantees that there are no incentives to jump to higher thresholds. The three main reasons behind this result are that the difference between the bonuses is not too high, the costs are sufficiently convex, and the cumulative distribution is sufficiently flat near the thresholds.

Last, for $\underline{\theta}_k$ to choose anything strictly between $\frac{\alpha f(\underline{\theta}_k)}{\gamma}$ and $\bar{\theta}_k - \underline{\theta}_k + \frac{\alpha f(\bar{\theta}_k)}{\gamma}$ is strictly dominated, because the rank does not change. The utility from choosing $\frac{\alpha f(\underline{\theta}_k)}{\gamma}$ is

$$\alpha F(\underline{\theta}_1) - \frac{\gamma}{2}\left(\frac{\alpha f(\underline{\theta}_1)}{\gamma}\right)^2, \text{ if } k = 1$$

$$\alpha F(\underline{\theta}_k) + m_{k-1} - \frac{\gamma}{2}\left(\frac{\alpha f(\underline{\theta}_k)}{\gamma}\right)^2, \text{ if } k \in \{2, \cdots, K\}$$

while the utility from choosing $b = \bar{\theta}_k - \underline{\theta}_k + \frac{\alpha f(\bar{\theta}_k)}{\gamma}$ is

$$\alpha F(\overline{\theta}_k) + m_k - \frac{\gamma}{2}\left(\overline{\theta}_k - \underline{\theta}_k + \frac{\alpha f(\overline{\theta}_k)}{\gamma}\right)^2, \text{ for all } k \in \{1, \cdots, K\}$$

By construction, these payoffs are equal.

Consider any individual with $\tilde{\theta}$ such that $\underline{\theta}_k < \tilde{\theta} < \bar{\theta}_k$. By the same reasoning as before, choosing any $b \notin \{\underline{\theta}_k - \tilde{\theta} + \frac{\alpha f(\underline{\theta})}{\gamma}, \bar{\theta}_k - \tilde{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma}\}$ cannot be optimal. If b is the former, then the payoff is

$$\alpha F(\underline{\theta}_1) - \frac{\gamma}{2}\left(\underline{\theta}_1 - \tilde{\theta} + \frac{\alpha f(\underline{\theta}_1)}{\gamma}\right)^2, \text{ if } k = 1$$

$$\alpha F(\underline{\theta}_k) + m_{k-1} - \frac{\gamma}{2}\left(\underline{\theta}_k - \tilde{\theta} + \frac{\alpha f(\underline{\theta}_k)}{\gamma}\right)^2, \text{ if } k \in \{2, \cdots, K\}$$

The payoff for the alternative is

$$\alpha F(\overline{\theta}_k) + m_k - \frac{\gamma}{2}\left(\overline{\theta}_k - \tilde{\theta} + \frac{\alpha f(\overline{\theta}_k)}{\gamma}\right)^2, \text{ for all } k \in \{1, \cdots, K\}$$

Relative to the payoff option for $\underline{\theta}_k$ types, notice that inside the quadratic term of the cost function, the $\tilde{\theta}$ type has a term $\underline{\theta}_k - \tilde{\theta} < 0$. Because of the convexity of the cost function, this implies a large cost decrease for the initially higher cost, which is attached to the higher b. This implies that the $\tilde{\theta}$

individual strictly prefers to set $b = \bar{\theta}_k - \tilde{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma}$. Formally, we also need F to be sufficiently flat around $\underline{\theta}_k$ and $\bar{\theta}_k$, for every $k \in \{1, \cdots, K\}$, so we can guarantee that the $\tilde{\theta}$ individual strictly prefers to set $b = \bar{\theta}_k - \tilde{\theta} + \frac{\alpha f(\bar{\theta})}{\gamma}$.

Fix $k \in \{1, \cdots, K\}$. Consider any type θ such that $\theta \in (\bar{\theta}_k, \underline{\theta}_{k+1})$. Assuming that the following inequality holds,

$$\frac{\gamma}{2}\left[\left(\underline{\theta}_{k+1} - \theta + \frac{\alpha f(\underline{\theta}_{k+1})}{\gamma}\right)^2 + \left(\frac{\alpha f(\underline{\theta}_{k+1})}{\gamma}\right)^2\right] > \alpha\left(F\left(\underline{\theta}_{k+1}\right) - F(\theta)\right)$$

i.e., assuming that F is sufficiently flat, then choosing $b = \underline{\theta}_{k+1} - \theta + \frac{\alpha f(\underline{\theta}_{k+1})}{\gamma}$ instead of $b = \frac{\alpha f(\theta)}{\gamma}$ is suboptimal. Hence, by the same reasoning used in Proposition E1, the agent will set $b(\theta) = \frac{\alpha f(\theta)}{\gamma}$ and $b(\theta) + \theta$ will be strictly increasing. Finally, if $[0, \theta_1)$ and the previous assumptions hold, we will have the same results as in Proposition E1, since the agents will face the same incentives. $\square$