Dear Boss, could you help me? A Model of "Reverse Delegation" in Corporations and Risk Aversion

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Abstract

Sometimes employees avoid taking actions or making decisions that their boss has previously delegated to them. Moreover, in some situations, employees return the task to the boss, who ends up doing it - despite employees were capable of performing the task. Among management practitioners and scholars this pathology is known as *Reverse Delegation* - with employees delegating on bosses - arguing that it can limit corporate efficiency and growth. This is the first paper to formally model such a mechanism in an economic model of the organization. Technically, we augment the Garicano (2000) model of hierarchies with a game that allows for such a Reverse Delegation, in this case motivated by employee's risk aversion when they make mistakes. More risk averse employees tend to delegate back more tasks, being detrimental to firm's productivity. Results point towards the relevance of task standardization and corporate confidence for productivity.

Keywords: Delegation, Reverse Delegation.

JEL classification: XXX, YYY.

Introduction

Due to limited time and bandwidth, managers delegate tasks to employees (e.g. Garicano, 2000). By doing this, the organization uses human resources more efficiently, performing tasks by the people that has comparative advantage on them, at the lowest opportunity cost within the organization. But corporate life is not always that easy. In real managerial situation, bosses who correctly delegated a task to a team member may receive the task back, despite the task is within the abilities of the employee. That problem is known in management practice as Reverse Delegation, sometimes called also Inverse or Backward Delegation.

In this pervasive problem, a manager can either face an employee that gives up the assignment entirely, or the more subtle case in which the employee brings so many problems, questions and decisions back that the manager is again carrying the weight of the assignment (The Harvard Business Review Manager's Handbook: The 17 Skills Leaders Need to Stand Out, 2017). Let's consider the following example[1]:

[1]Example from Bernd Geropp's website: https://www.berndgeropp.com/upward-delegation/

As the manager, you delegated an important task to Jack last week. He was supposed to carry out this final tasks for Project XYZ by the end of next month. This project is very important because it will bring prestige to the organization (and possibly will pave the way for other highly profitable projects), but if not done, or done incorrectly, will cause problems with regulatory institutions. Jack knows this kind of project well and has all the information about it. He is also aware of the related risks. You have complete confidence in him, but you are not sure of his abilities. That's why you agreed with him that he only briefly reports back when he's finished and the project is done. Today you are focusing on your own tasks and problems. But suddenly, Jack enters to your office: "Boss, I'm sorry to interrupt you but I've got a problem. I'm supposed to perform the last task of that project. I've put something together, and I've done all I can, but somehow I'm not getting anywhere. I think I'm not able to finish this one because I'm not capable of. But you know XYZ very well. Could you take a quick look at what I've done and perhaps help to finish it off?". How do you react? Sure, you're the expert on Project XYZ, but you delegated to Jack for a reason. You just think: "Maybe I was wrong with Jack, he is not capable of taking care of the project". So you're answering: "OK. Jack, give it to me. I'll deal with it later". You have another task on your desk :– a task that you had actually delegated to your employee.

Reverse Delegation can be detrimental not only for the manager, who has now less time to work on the tasks he has comparative advantage with; but also for the productivity of the entire organization (Christensen et al., 2017).

This phenomenon is pervasive and recurrent, as remarked in the management literature. However, there is still little consensus on how to fight this problem. In that context, having a formal model, where Reverse Delegation is the equilibrium of a game with asymmetric information and risk aversion, could be a useful step to pin down channels and simulate alternative policies to mitigate the problem.

Beyond single corporations, our work may also relate to the macroeconomic differences in productivity across nations. For instance, Hsieh and Klenow (2014) show that firms in some emerging and developing countries tend to scale up very little, when compared to firms in, let's say, the US. In related papers, the World Management Survey (2014) showed how in some countries there is too little delegation by managers. Our contribution to this debate is that too little definition of tasks in the organization, combined with risk aversion by employees, may lead to too excessive Reverse Delegation, lagging behind productivity in emerging countries. In the model, we propose that Reverse Delegation can be a sort of defensive behavior of the employee when he faces risky situations.

To model Reverse Delegation, we augment the model presented by Garicano (2000) and Bloom et al. (2012), allowing for the boss' imperfect knowledge of the maximum skill of the employee, added to the employee being scared about making a mistake.

The classical 1974 Harvard Business Review article entitled "Management Time: Who's Got the Monkey?" was one of the pioneers in acknowledging the problem, although the name of Reverse Delegation was coined afterwards. From there on, several articles addressed the problem (e.g. Muir, 1995; Tracy, 2011, 2013; the Harvard Business Review Books Manager's Handbook: The 17 Skills Leaders Need to Stand Out, 2015, and The HBR 20-Minute Manager Collection, 2016), but they consider Reverse Delegation as a minor issue that should be solved by managers and managers alone. Moreover, no paper has addressed this issue from a rigorous or theoretic view, not even in economics literature.

We acknowledge that there might be other models creating Reverse Delegation, that is why our title is "A model", never claiming this represents the only possible mechanism. The Appendix offers a brief narrative overview of alternative channels[2].

Bloom, Sadun & Van Reenen (2012) adapted the Garicano (2000) framework of hierarchies to argue that trust among individuals was important for productivity and delegation. Our take is that some other force, like risk aversion and task risk/punishment, could have similar effects on productivity. Beyond the differences in our theory, our model has different root causes of the productivity gap, and therefore it suggests a rationale for different type of interventions. Instead of boosting trust, the interventions that could mitigate reverse delegation in our model are those that reduce the risks of the task (i.e. Standard Operating Procedures, ISO 900 Process Certification) or that mitigates the excessive costs for the employee in case of a mistake.

The rest of the article is organized as follows. In Section 2, as a preamble of the model, we present a narrative on how the Reverse Delegation can be perceived as a defensive practice. Next, section 3 shows our basic model. Section 4 discusses implications of the model for managers and organizations. Finally, Section 5 offers concluding remarks, suggesting avenue for further research.

Reverse Delegation as a Defensive Practice

In the context of patient-physician relations there has been reports of excesses in "defensive pratices" (Harris, 1987), taken by physicians as to avoid malpractice lawsuits, for example. Whittaker et al. (2015) defined "defensive practices as those practices which are deliberately chosen in order to protect the professional worker, at the possible expense of the well-being of the client". That would be, for example, ordering many

[2] In that section, A.1 of Appendix, we compare similar problems of Reverse Delegation with what we are modeling here, and highlight the differences of those scenarios with our setting.

additional exams that add little value to the patient, but that would disproportionately reduce the downside of the physician in case of a random error.

However, this definition of Whittaker et al. was given in a context of social work professionals. The issue has not been discussed in the organizational economics literature, and yet can prove to be a plausible cause for Reverse Delegation. Brought to an organizational context, these defensive practices are chosen by the employees in order to protect themselves, at the expense of the boss and the well-being of the organization. Furthermore, our point here is that Reverse Delegation is indeed a defensive practice: the risk averse employee wants to protect himself by delegating back tasks (whose execution is uncertain), so he is not held responsible in case something goes wrong (because the punishment or the likelihood of bad perfomance can be too high).

As Munro (2010) noted, "many of the problems in current practice seem to arise from the defensive ways in which professionals are expected to manage uncertainty. For some, following rules and being compliant can appear less risky than carrying the personal responsibility for exercising judgment". Individuals incur in defensive practices as an "insurance" to their risk exposure[3]. In our model the risk averse employee prefers to bring back the task to the boss, in a way that does not seems like the employee is shirking from work but asking for help. So this is not a model about moral hazard.

Scholars have identified different types of defensive practices (Managing People During Stressful Times: The Psychologically Defensive Workplace, 1997). These practices start with stressful announcements and trigger anxious responses, such as overworking when in fear of getting fired, or reverse delegating when having to deal with uncertainty, for example. Even defensive practices can be found when a cultural/organizational change occurs (Argyris, 1999). The practices can also be used by a group within the (if not the entire) organization, when trying to avoid impacts on the corporate reputation (Carberry et al., 2012). The point is that defensive practices can be quite common, so is highly plausible to encounter Reverse Delegation being caused by a risk averse behaviour of employees in day to day.

Some industries may tend suffer more from Reverse Delegation caused by risk aversion than others. But just to clarify, our focus is in the inefficiently conservative actions taken by the employee. Let's explain: in some cases the whole organization may lose a lot if there is an error in the finished product, for example because the hospital could be sued or the corporate reputation is at stake. In those cases a higher investment in preventing problems is optimal for the organization. Financial institutions, health organizations and other firms subject to regulation may

[3]Although we are aware that the concepts are not the same, we will use indistinctly risk and uncertainty to refer to the same thing.

have “more anxious responses”, as suggested by Hrebiniak et al. (2017), indicating Reverse Delegation may occur more often. In this paper, in contrast, we focus mostly on cases in which the employee ends up being disproportionately more cautious that what the organization would want. This is because they fear personal costs of performing the risky task, in the scenario of a mistake. This type of agency problems may reduce productivity and prevent scale-up the organization.

Lastly, the excess of reverse delegation is only plausible if the boss cannot perfectly identify whether the task is really too difficult for the employee, otherwise the boss can re-delegate it. This will be an important ingredient for the model in the next section.

Theoretical Model

Basic Setting

We begin by assuming organizational dynamics similar to Garicano's model (2000): organizations are composed by many hierarchies, where each of them will be specialized in solving tasks and decisions that must be faced. From this model we conclude that the higher (lower) the hierarchy is, the higher (lower) is the skill of the individual that is in that hierarchy. As a result, the simplest (most common) problems and tasks to solve will be solved by the lower levels of the hierarchy. In order to correctly model the situation, it will be the highest hierarchies that decide tasks, and will be they who delegate. To simplify, suppose that there are two hierarchies with only one individual in each, an agent and a principal, where the latter is the one who delegates tasks to the first.

Let $Z \subseteq \mathbb{R}_+$ be the set of all possible problems that must be solved, in which also the skills of the individuals will be defined: z_a is the agent's (employee) skill, and z_p is the principal's (boss). Clearly we must have that $z_a < z_p$, i.e., the skill of the principal is greater than the agent's. We define $z_i \in Z$ as the necessary skill to solve, in principle , correctly the task i. So, if the employee can solve any task i with difficulty z_i such that $z_i \in [0, z_a]$, then the boss can solve that task i too, but the conversely is not always true. Note that the skill is a quantity: the greater the skill z of an individual, harder tasks can be performed correctly by that individual.

To produce in this organization it is required that problems, decisions and tasks must be solved either by the principal or the agent, and this will happen when any task i is doable: i.e., when $z_i \in [0, z_p] \subseteq Z$. Now, let F be the cumulative distribution function with support in $[0, z_p] \subseteq Z$[4]. We will assume for simplicity that this distribution is continuous and non-atomic, and that the corresponding density function f exists. Normalize this density so that f is non-increasing. In other words, the probability

[4] We assume the support to be $[0, z_p]$, because any task more difficult than z_p cannot be solved within the organization.

of occurrence of z_i decreases if z_i is higher (more difficult tasks are less likely to happen). Figure 1 shows the situation with tasks and skills.

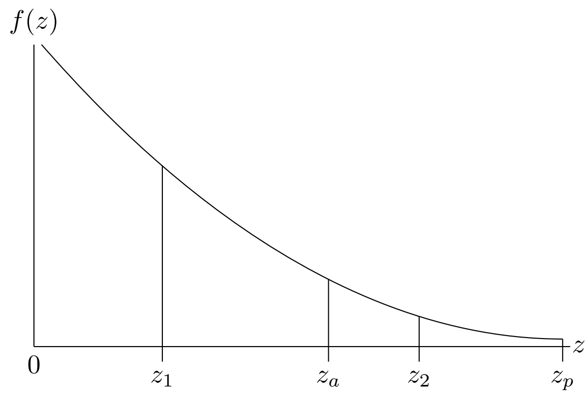
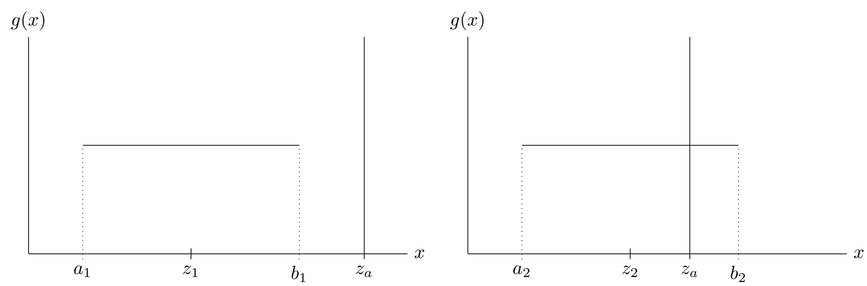


Figure 1: Density of the distribution of tasks. z_p is the skill of the principal, z_a is the agent's skill. z_1 is a task that both individuals can solve, while z_2 is a problem that only the principal can solve.

So far we have added nothing new to Garicano's model; we have just used it to model the relationship between boss and employee. Our addition is the following: we allow for a game between those two, and we add uncertainty in the execution or performance of tasks. First, as we know, the principal faces tasks and is able to solve any task i such that $z_i \in [0, z_p]$, but he will want to dedicate himself to those more difficult tasks that can only be solve by him, while delegating the rest to the agent. However, the principal does not know exactly what the skill of the agent is because it is *noisy*, so he sometimes will delegate tasks that the agent cannot solve (and the principal is aware of this). Consider z_a^e as the expected ability that the principal thinks the agent has, so delegation will happen when the task or decision i has a difficulty of $z_i \leq z_a^e$. We wil define $z_a^e = z_a + u$, where u is the noise of the skill (with $E(u) = 0$ and $E(u^2) = \sigma_u^2$) and $\lambda = 1/\sigma_u^2$ is the precision (which is observable by both). Due to this noise, and as the agent is able to return the tasks, the principal will want him to delegate back those tasks that are difficult to the latter, i.e., those tasks i such that $z_a < z_i$, as this ensures that the task will not be solved incorrectly. On the other hand, the principal expects the agent to perform the tasks when $z_i \leq z_a$, because in that case the latter will be able to solve the task correctly. However, there will be uncertainty (for both the agent and the principal) in execution: if the task i, where $z_i < z_a$, is delegated to the agent, the execution of the task will be $x \in Z$, where x distributes according to a distribution G with mean z_i. This x can be thought as a measure of quality of the job: if x turns out to be equal to z_i, then the agent does exactly what is necessary to perform the task correctly. If $x < z_i$, the agents performs correctly, but in a *sloppy* way, while if $x > z_i$, the agent does more things than needed, but performs correctly nonetheless. The problem arises when z_i is so close to z_a, that x might fall above z_a. If $x > z_a$, the agent executes the task incorrectly (the quality exceeds what he is capable of, so he performs badly). We will say that there is a great risk of execution if $Pr\{z_a < x\} > Pr\{x \leq z_a\}$. The whole situation is depicted in Figure 2.



(a) x always falls below z_a

(b) x might fall above z_a

Figure 2: Execution x_i of task z_i, assuming $x_i \sim G = Uniform[a_i, b_i]$, where $(a_i + b_i)/2 = z_i$, $\forall\ i \in \{1, 2\}$. In panel a), it does not matter where x lies, because the agent will always execute the task 1 correctly. In panel b), x can fall above z_a, so there is a risk of executing the task 2 incorrectly.

Now, we will build on the Bloom et al. (2012) model. In that paper, they add a belief effect on the agents, which will ultimately have an effect on the productivity of the firm and its size. In this paper, however, we will add a risk aversion effect that, similar to the aforementioned model, will have an effect on productivity and size, but unlike it, this risk aversion comes from the very agent. In this way, and given this setting, the willingness to perform the tasks by the agent will be a function of their risk aversion related to the difficulty of the task, the uncertainty of performance of the task and the cost of performing incorrectly. Thus, the following may occur: the principal delegates a task that the agent can solve most of the times, but the latter prefers to return the task without doing it because he is afraid of doing it wrong[5].

The difference of objectives arises when the agent alleges that he can not perform tasks. However, he will not return tasks that are simple (low difficulty), because there is no risk of performing them wrong and the cost of reverse delegating is evitable this way (panel a) of Figure 2). On the other hand, he also knows that his skill is not observed accurately by the

[5] We know there exists a problem where the agent does not return and performs a task that is above its capabilities, but it will not be discussed here.

principal, so very difficult tasks, which are close to his level of ability, may be returned without always being discovered: i.e., there are times when the principal will believe him, while there will be others when he will not. Finally, any task that exceeds his ability will be returned. In this way, we define the difficulty of tasks, the cutoff, for which any task above this point will be returned, while tasks below this point will be performed, given that this point is less than z_a.

We will call this cutoff $\underline{z}$, with $\underline{z} < z_a$. In summary, any task i such that $z_i < \underline{z}$ will be solved, while any task i such that $\underline{z} \leq z_i$ will be delegated back. The principal may infer that, if the i task is not returned, then $z_i \in [0, \underline{z})$, but if it is returned, he will know that $z_i \in (\underline{z}, z_p]$. Define $p(\lambda)$ as the probability that the principal monitors the agent. We should expect that this probability depends on λ (as we will see later). We consider this monitoring as any procedure that always ends up uncovering truthfully if the agent was capable or not of solving the task at hand. So, we have three critical areas in the interval $[0, z_p]$:

a) $[0, \underline{z})$: The task is not returned, and solved by the agent. Objectives are aligned[6].

b) $[\underline{z}, z_a]$: The task is delegated back. The principal catches him with probability $p(\lambda)$, but does not monitor him with probability $1-p(\lambda)$. Objectives are not aligned: agent can sometimes perform the task, but prefers to not to.

c) $(z_a, z_p]$: Task is always returned. Although objectives are aligned, because tasks are not solved incorrectly, the principal can still doubt: with probability $p(\lambda)$ he monitors and learns that the agent was not capable, so monitoring was pointless.

This situation is depicted in Figure 3.

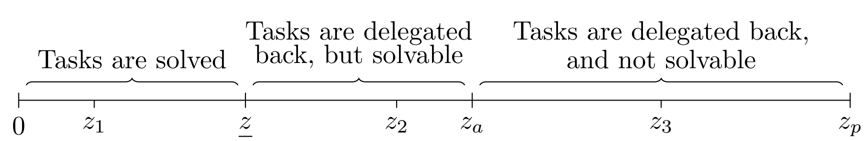


Figure 3: z_1 is a low difficulty task, so it will be solved. z_2 is a task that can be solved, but it is delegated back. z_3 is a very difficult task for the agent, so it will be delegated back.

We define the timing of this game, where:

t=0 : Principal offers a contract and wage to agent, which the latter accepts. Principal delegates task i such that $z_i < z_p$ to agent.

[6]Expresión en español es "objetivos alineados", no estoy seguro si está bien traducida

t=1 : Agent decides whether to delegate back the task or not to the principal, evaluating z_i, $\underline{z}$ and z_a, and then informs the boss.

t=2 : Principal receives back (or not) the task assigned to the agent according to what the latter decided on $t = 1$, and exerts (or not) the monitoring. Payments are executed.

The timing sums up the situation up to this point.

Utility Functions of Individuals

Now, we turn to define the probability $p(\lambda)$. To do this, we define the expected utility of the principal when $\underline{z} \leq z_i \leq z_a^e$. We have:

$$U_{principal} = (1-p)\cdot \underbrace{(\beta z_i)}_{\text{when he does not monitor}} + \underbrace{p\left(Pr\{x \leq z_a\} \cdot z_i + \alpha - \frac{Kp}{\lambda}\right)}_{\text{when he does monitor}} \tag{1}$$

where p is the probability of monitoring, $\beta \ll 1$ is the loss of efficiency due to having to solve the task that the agent delegated back, K is the cost incurred by the principal for monitoring the agent when the latter is returning the tasks that effectively can not perform (a cost of a *type II error*; it is reduced by the precision λ with which he observes the agent's skill, and weighted by the same probability of monitoring the agent, since he will not always be delegating back tasks that the agent can solve), $\alpha > 0$ is a variable that sums up the positive effects over efficiency (because now the agent will be more careful when delegating back tasks that can be solved). Note that when the principal monitors, the agent will have to solve the task, so it is weighted by $Pr\{x \leq z_a\}$.We can derive the optimal probability p:

$$p \in \text{ argmax } U_{principal} = [1-p](\beta z_i) + p\left(Pr\{x \leq z_a\}z_i + \alpha - \frac{Kp}{\lambda}\right)$$

$$\Longrightarrow p^*(\lambda) = \frac{\lambda}{2K}[(Pr\{x \leq z_a\} - \beta)z_i + \alpha] \tag{2}$$

This is the optimal probability of monitoring of the principal, and is different for every task i received back (it does depend on z_i, but it does not on $\underline{z}$). Note that the principal will not always monitor, because of the precision λ not being perfect, and he knows that the execution is not perfect (n)either. Next, we turn to determine $\underline{z}$. Define the utility function of the agent within the range $[0, z_a]$[7]: if the agent decides to solves the delegated task, and it turns out well, his utility will be defined by:

$$U_{agent} = (z_a - z_i)^{1-\gamma} \tag{3}$$

[7] We do not define the utility on the range $(z_a, z_p]$, because the optimal strategy there is always to delegate back.

where z_a is the skill level of the agent, z_i is the skill required to solve the task i, and γ is his level of risk aversion. The idea behind this function is that the agent gets more utility while the task is simpler to perform or solve. Note that the difference between z_a and z_i is inside a utility function with a constant relative risk aversion. However, recall that the execution is stochastic: sometimes can be done incorrectly (or quality is not good enough). If we assume x as the variable that denotes quality of performance or execution, the utility when the agent tries to solve the task is:

$$U_{agent} = Pr\{x \leq z_a\} \cdot (z_a - z_i)^{1-\gamma} + Pr\{z_a < x\} \cdot (-\eta) \tag{4}$$

where $\eta > 1$ is the cost, or punishment, of performing the task wrong. We call $Pr\{z_a < x\} \cdot (-\eta)$ the expected cost of bad execution, and is one of the main ingredients of the model.

Besides performing, the agent can delegate back, and if he does, he assumes a cost of δ, but only if the principal monitors him. Thus, the utility of delegating back is $p(\lambda)\delta$ (we will assume that $\eta \gg \delta$, so the cost of reverse delegation is less than performing tasks incorrectly[8]). With this, we are able to determine $\underline{z}$ when the agent is indifferent between performing the task and delegating it back. Substituting z_i with $\underline{z}$, we define the indifference equation as:

$$Pr\{x \leq z_a\} \cdot (z_a - \underline{z})^{1-\gamma} + Pr\{z_a < x\} \cdot (-\eta) = p(\lambda)\delta$$

Solving for $\underline{z}$, we get:

$$\underline{z} = z_a - \left(\frac{Pr\{z_a < x\}\eta - p(\lambda)\delta}{Pr\{x \leq z_a\}} \right)^{\frac{1}{1-\gamma}} \tag{5}$$

This expression is our cutoff: any task i such that $z_i > \underline{z}$ will be delegated back, while any task i such that $z_i < \underline{z}$ will be executed. Note that when $Pr(x \leq z_a) = 1$ (that means $Pr(z_a < x) = 0$), i.e. the agent is sure that he will always be capable of doing the tasks, he will define $\underline{z} \geq z_a$; that is, he will not reverse delegate when $z_i < z_a$[9].

Definition of Equilibrium and First Results

To find the equilibrium of this game, we apply backward induction. First, in t=2, the principal defines the optimal monitoring rate, given by equation 2:

$$p^*(\lambda) = \frac{\lambda}{2K}[(Pr\{x \leq z_a\} - \beta)z_i + \alpha]$$

Next, in t=1 the agent defines $\underline{z}$ at which he starts to delegate back, given by equation 5:

[8] This seems sensible, and is needed for the proofs. In the next section we will discuss about this assumption.

[9] This also means that he will be performing the tasks i such that $z_i > z_a$, but we said earlier, we will not model this here.

$$\underline{z} = z_a - \left(\frac{Pr\{z_a < x\}\eta - p(\lambda)\delta}{Pr\{x \leq z_a\}} \right)^{\frac{1}{1-\gamma}}$$

So, before receiving the task, the agent defines $\underline{z}$, given his own skill, the risk aversion degree and the uncertainty of execution[10]. Later, the agent receives the task and decides if return it back or not. Then, for every task i reverse delegated, the principal defines the probability at which will monitor the agent. With both equation, we are ready to present our results. From deriving equation 2 with respect to λ , we get the first proposition.

Proposition 1: *The likelihood of monitoring by the principal increases when the agent's skill is observed with more precision by the principal*[11].

When λ increases, the principal will want to monitor more often:

$$\frac{\partial p(\lambda)}{\partial \lambda} > 0$$

This is sensible, because when the principal knows very well the skill of the agent (i.e., λ is high enough), if he receives a task back, he will want to investigate why the agent reverse delegated, given that he was sure that the agent was capable of performing, so the probability of monitoring will be higher. Also, because of $\lambda = 1/\sigma_u^2$, we have that:

$$\frac{\partial p(\lambda)}{\partial \sigma_u^2} < 0$$

Next, by deriving equation 5 with respect to γ, we present the next proposition.

Proposition 2: *Higher risk aversion from the employee leads to a greater number of tasks reverse delegated, but only if the expected cost of bad execution is excessively high. If not, risk averse individual will not reverse delegate.*

The cutoff point $\underline{z}$ decreases if the agent is more risk averse (if γ rises), but only if $Pr\{z_a < x\}\eta > p(\lambda)\delta + Pr\{x < z_a\}$. This makes sense: if doing a mistake is way too costly, then the risk averse agent will want to delegate back. But if $Pr\{z_a < x\}\eta < p(\lambda)\delta + Pr\{x < z_a\}$, the agent will delegate back less, because he will avoid both costs doing so. So:

$$\frac{\partial \underline{z}}{\partial \gamma} < 0 \text{ , only if } Pr\{z_a < x\}\eta > p(\lambda)\delta + Pr\{x < z_a\}$$

This result tells us that the more risk averse the individual is, the more tasks will be delegated back, or only the simpler tasks will be solved. This can have negative effects on the productivity of the organization: given great uncertainty in execution or excessive bad performance cost, greater

[10]We will discuss what we mean with uncertainty of execution later.

[11]The proof of this and other propositions can be seen in the Appendix, section A.2.

aversion to risk in employees (putting them in situations of high stress, establishing huge punishments in case of mistakes, etc.) will lead to important efficiency losses, because now the boss will have to take on tasks or decisions that were delegated in the first place.

Deriving $\underline{z}$ with respect to λ, we present the following result:

Corollary 1: *More precision in the agent's skill causes less tasks to be reverse delegated.*

$$\frac{\partial \underline{z}}{\partial \lambda} > 0$$

Let us explain the extreme case: if the principal knows exactly the skill of the agent, the latter will want to behave correctly and return only tasks that he cannot perform, because otherwise he will always be admonished. A reduction of noise (or better precision) is good for the principal and for the organization.

Effects on Productivity

Following Bloom et al. (2012), and as defined before, $Z \subseteq \mathbb{R}_+$ is the set of all the possible tasks that individuals can face (where it is assumed that the greater the $z_i \in Z$ is, the task i is of greater difficulty and requires a higher skill level to be solved). The principal can solve all those tasks such that $z_i \in [0, z_p] \subseteq Z$, while the agent can solve *potentially* those tasks such that $z_i \in [0, z_a] \subseteq Z$. We will have that F is the cumulative distribution function defined on $[0, z_p] \subseteq Z$, where f is the corresponding density function (with all the previously described assumptions).

In order to illustrate how we will represent productivity, consider the situation in which only the principal is working within the organization. The expected output, $E[y]$, will be:

$$E[y] = Pr\{z_i \leq z_p\} - c(z_p)$$

where $c(z_p)$ is the normalized cost of having an individual of skill z_p in the organization (such as wage). If we assume that $F(0) = 0$, we can rewrite the previous expression as:

$$E[y] = F(z_p) - c(z_p) \tag{6}$$

Once we add an agent (who can delegate back the tasks assigned by the principal, and we will assume that when agent performs incorrectly, the principal will have to take care of the task), we will have:

$$E[y] = \underbrace{Pr\{z_a^e < z_i \leq z_p\}}_{\text{principal's tasks}} + \underbrace{Pr\{0 < z_i \leq \underline{z}\}}_{\text{agent's tasks}} + \underbrace{[1 - p(\lambda)]\beta Pr\{\underline{z} < z_i \leq z_a^e\}}_{\text{if the agent is not monitored}}$$
$$+ \underbrace{p(\lambda) Pr\{x \leq z_a\} Pr\{\underline{z} < z_i \leq z_a^e\}}_{\text{if the agent is monitored}} \quad \underbrace{- c(z_a^e) - c(z_p)}_{\text{costs of having agent and principal}}$$

where we note that $p(\lambda)$ is the probability of monitoring, $Pr\{x \leq z_a\}$ is probability of execution of the tasks, and β is the loss of efficiency when the principal solves tasks that he had delegated to the agent. With a bit of algebra and replacements, we rewrite:

$$E[y] = F(z_p) + (F(\underline{z}) - F(z_a^e))(1 - \beta - p(\lambda)[Pr\{x \leq z_a\} - \beta])$$

$$-c(z_a^e) - c(z_p) \tag{7}$$

This expression will be the expected output in the situation with only one agent and one principal. We get that:

$$\frac{\partial E[y]}{\partial \underline{z}} > 0$$

This shows us that, the greater this cutoff point is, the greater the expected output of the organization will be. We can also see that $\frac{\partial^2 E[y]}{\partial \underline{z}^2} < 0$ (recall that f is non-increasing). With this, we present the following result.

Proposition 3: *The expected output decreases when the agent is more risk averse and the expected cost of bad execution is excessively high.*

$$\frac{\partial E[y]}{\partial \gamma} < 0$$

Using proposition 2, and as we mentioned before, we prove that the more risk-averse is the agent, greater is the decrease in the expected output. Furthermore, using corollary 1, we get a relation between the precision of the agent's skill and the expected output of the organization.

Corollary 2: *The more precise is the skill of the agent, the greater is the expected output.*

Being the principal able to observe the agent's skill with more precision, there will be a positive effect on the productivity of the organization.

$$\frac{\partial E[y]}{\partial \lambda} > 0$$

Size of the Organization

Now we turn to the problem of more than one agent receiving tasks form the principal. The agents, that we assume to have the same skill level and risk aversion degree, continue to behave like what we have modeled before; it is the principal who now faces a new problem: he must decide the number of people that he has in charge. Following Garicano (2000) and Bloom et al. (2012), the principal must meet his *expected time* budget constraint:

$$[\underbrace{Pr\{\underline{z} < z_i \leq z_a^e\}}_{\text{tasks reverse delegated}} n + \underbrace{Pr\{z_i > z_a^e\}}_{\text{tasks that only the principal can solve}}]h$$

$$+ \underbrace{mp(\lambda)n}_{\text{time spent monitoring}} = 1$$

$$\implies [(F(z_a^e) - F(\underline{z}))n + 1 - F(z_a^e)]h + mp(\lambda)n = 1 \tag{8}$$

where n is number of employees, h is the time cost of producing, m is time cost of monitoring and $p(\lambda)$ is the probability of monitoring. We normalize the total time available to 1. So now we can derive the optimal size of the organization[12]:

$$n^* = (1 - (1 + F(z_a^e))h) \cdot \frac{1}{(F(z_a^e) - F(\underline{z}))h + mp(\lambda)} \tag{9}$$

With this, we have:

$$\frac{\partial n^*}{\partial \underline{z}} > 0$$

And we get our last result:

Proposition 4: *The size of the organization decreases when the agents are more risk averse and the expected cost of bad execution is excessively high.*

$$\frac{\partial n^*}{\partial \gamma} < 0$$

The idea behind this result is that the more risk averse are the agents, employees are not worth hiring, so the firm will prefer to stay small. And:

Corollary 3: *Firm's size increases when the precision of skills increase.*

$$\frac{\partial n^*}{\partial \lambda} > 0$$

The more precise is the agent's skill, the principal will prefer to increase the size because he will know if they can solve tasks correctly, given that there is no risk of having free-riders. Another interpretation is that with more risk aversion, more principals are needed to exert monitoring over agents, so the organization will need to hire more bosses.

Discussion

What we have shown is that risk aversion as a whole is negative for the firm, from having great and obvious impacts to having little and more subtle effects in other ways. For example, the straightforward implication of the second proposition is that risk aversion causes more Reverse Delegation, and this, paired with proposition 3, ends up in risk aversion causing lesser productivity. That is, given that the probability of executing the tasks wrong is considerable and the cost of performing incorrectly exceeds the cost of reverse delegating. This is the main conclusion that

[12] We need that $1 - (1 + F(z_a^e))h > 0$, otherwise n^* will not be a positive number.

we would want to highlight: risk aversion, paired with high bad execution cost and/or uncertainty, through Reverse Delegation, leads to less tasks done, and this means that the organization will have to take more time to produce. Seeing Reverse Delegation as a bad management practice (even resulting in no delegation at all), this channel could explain why do firms in developing countries have low productivity (Bloom et al., 2010), since developing countries have greater risk aversion coefficients (Alderman et al. 1994, Gandelman et al. 2015). We still have to see if this implication remains true when tested directly. Other indirect effect is the size of firms with risk averse employees. Our proposition 4 shows that firms are smaller when employees are more risk averse, and this can also be an explanation on why firms with bad managerial practices are small (Bloom and Van Reenen, 2010). However, this could not mean a bad thing by itself. Sure, not growing when they should is a negative effect, but also could only mean that more bosses/supervisors are needed, and this leads to bigger firms (although not in the hierarchy needed to produce more efficiently). We should note that, by equation 5, $\underline{z}$ increases when z_a does, and with proposition 4 it could explain why better educated employees tend to be hired by larger firms, and have greater returns to education (Evans and Leighton 1988). Also, with proposition 3, highly skilled individuals can help to achieve greater productivity, as some evidence has shown (Blundell et al., 2005).

Focusing on the noise of agent's skill and precision of its observability, proposition 1 tells us that the boss will want to monitor less often when the capabilities of the employee are more noisy (observed with less precision), but what do we mean with a noisy skill? When the organization hires a new employee and, for instance, he has no past experiences on the position or the hiring department could not get the information of former jobs, the boss will not be fully sure what the employee is capable of. With noisy skill we refer to that kind of situations. The boss will want to know why the agent could not perform or solve the tasks/decisions, hence the monitoring. Furthermore, the employee can take advantage when the principal has incomplete information about his skill. Corollary 1 shows that when the skill is observed with less precision, the agent will reverse delegate more tasks, and this reduces productivity (by virtue of corollary 2), and corollary 3 tells us that in this situation, the organization will hire less employees (or more bosses). In the end, noisy skills only make things harder for boss on the day to day work. Also, the derived probability at which he will monitor the agent can also be thought as the demand or necessity for micromanagement. Recall that the probability also depends of the difficulty of the task z_i, so if the task is harder, the likelihood that the boss should go supervise the agent is higher. Micromanagement can be detrimental for the organization: employees needing supervising will deplete the time budget of the principal too.

We also have modeled the uncertainty in execution, and we are able to get our results when we consider risk averse individuals facing this uncertainty. It may in comes in many forms: for example, the employee is insecure about the processes needed to fulfill the task. Clearly, the uncertainty comes from a lack of information for the job, and the obvious solution is to provide the information needed. One way to do this is to standardize the steps needed. In the terms of the model, this means to reduce the variance of the distribution G (recall that the execution, x, distributes according to G), and also to make $Pr\{x \leq z_a\} > Pr\{z_a < x\}$, as this *empowers* the agent to perform the task correctly. In other situations, an example is when the uncertainty in execution cannot be reduced, and the agent is evaluated by the success or failure of the project. In this case, the solution comes from evaluating the success of the employee's tasks in average, so he can hope, ex-ante, to offset the failures with the successes. However, it may not always be efficient to reduce the variance of G at its minimum, because the perceived cost of the agent of performing wrong can be different of the cost of the organization of having a tasks incorrectly solved. If the cost of the organization is greater, then it is better for the principal to have an agent that reverse delegates sometimes, so this one cost is avoided.

One interesting feature of our model is that it predicts the Reverse Delegation/risk aversion phenomenon in equilibrium; that is, there always will be Reverse Delegation when individuals act in their best interest, and this is because of the risk aversion degree of the employee. As we have said, even when the employee is capable of solving the task/decisions, he will want to take the task back to the boss's office just to protect himself from uncertainty. But how come the boss does not anticipate this and avoids delegating harder tasks, knowing that if he does the tasks will be delegated back? The answer is that the skills are noisy, the execution is uncertain, and the risk aversion degree is unknown. When the employee has been recently hired, the boss may have a vague idea of what the employee's skill is, but has no idea at all about the risk aversion degree of the employee, so the boss may believe that the risk aversion is not that high. Certainly, the boss will learn the skill and risk aversion degree over time, as he delegates tasks and receives back some of them, but the process may be slow when tasks take days to be performed (and this means that harder tasks can lead to slower learning processes for the manager).

One use for the results is that they can tell managers what can be the sources of Reverse Delegation and low productivity, so they can act to fight them. For example, take the Reverse Delegation problem. Here, we propose that risk aversion, high costs of bad execution and uncertainty can be a cause for Reverse Delegation, so fighting them can be a sensible thing in this case. The boss can support (communicating confidence on employee's capabilities), provide background information about the task, standardize the processes, propose meetings to answer questions about the task at hand, and give better work conditions so that the worker does not perceive that much uncertainty. For noisy skill problem, the organization can be more "picky" with their employees, and only hire those that have a lot of experience in similar jobs, so the noise becomes small.

We have stated some conclusions here, but they need to be tested empirically. If we could have access to data that measured individual risk aversion and uncertainty in execution, the Reverse Delegation at hierarchy or organization level, and if we could link this to productivity of firms, we would have the perfect data set to conduct the empirical test. However, to our best knowledge, such data does not exist, and carrying out the interviews to collect the data seems not feasible.

Concluding Remarks

Why are firms not as efficient as they could be? Why do they not grow as much as they should? This paper examine one possible explanation to this problem. Starting from Garicano's model (2000), what we present here is an alternative hypothesis to answer the questions that have puzzled many others and has encouraged an enormous amount of literature about growth and efficiency of firms. Our intention is just to show one other reason that has been ignored in that literature until now. With this, we hope to start a new investigative line about Reverse Delegation and its relation with other causes that impact in firm's production.

Thanks to the model developed here, we are able to investigate the effects of risk aversion and uncertainty on delegation of firms. The main results tells us that when agents are more risk averse, they tend to delegate the tasks back to the bosses, causing loss of efficiency. Because of this, in return, we should expect less tasks delegated to them by the bosses. Even more, our results predict that organizations will be smaller and will not produce as much as they could. This is interesting because shows that, in theory, Reverse Delegation is actually a practice that can be detrimental to firms, and this could partly explain why some organization/industries do not grow as they should, and that could be explained by their culture, where individuals tend to be more risk averse.

As we present this article as a novelty and only formalize a concept that has been not widely known outside the organization literature, certainly there is so much that can be done from now on starting from here. Other causes that trigger the Reverse Delegation phenomenon can be explored. Not only that, an empirical analysis can be conducted if the right data is collected. With this, we would be able to test the implications of our results, and provide evidence that Reverse Delegation is indeed a harmful practice that needs to be fully understood and taken into account.

Appendix

A.1

Here, we present causes for Reverse Delegation that can appear to be similar to what we model here, but are different from risk aversion.

Problem	Description	Differences with our model
Incompetent Employee[13]	He will never be capable of performing the tasks because he does not have the necessary skill, so he always reverse-delegates	The employee delegates back because he does not know how to do the task, but in our model he is always somewhat competent.
Insecure Employee[14]	He does not know *exactly* what his skill is, so he is not sure if he will be able to perform	This is a second source of risk, because he can be insecure about his own skill, and other separately source of risk is the uncertainty of the task.
Lazy Employee[15]	He will not do his job if he is able to delegate back, so he always returns to the boss the task/decision	No matter what kind of job or if he has the skill or not, the employee will return even the easiest tasks.
Busy Employee[16]	He is overwhelmed with the workload, so any other task will not be performed, thus reverse-delegated	In our model, the reason why the agent delegates back is to protect himself, but not because he is full of work.

A.2 (Proofs)

Proofs for all of our propositions and corollaries. Throughout the proofs, we will use the following *probabilities* conditions:

i) $\frac{\partial Pr\{x \leq z_a\}}{\partial z_i} < 0$: We should expect the probability of correct execution to decrease when the difficulty of the task at hand rises.

ii) $\frac{\partial Pr\{x > z_a\}}{\partial z_i} > 0$: On the contrary, we should expect the probability of incorrect execution to increase when the difficulty of the task at hand rises.

It is obvious that when condition i) is met, then the condition ii) will also be met. We stated earlier that the distribution of x is G with mean

z_i, but we did not declare what was this G distribution. We need G to be any distribution such that i) and ii) are met. For instance:

a) If $G = Uniform[a, b]$, where $\mu = z_i = \frac{a+b}{2}$ and $\sigma^2 = \frac{(b-a)^2}{12}$, the cumulative distribution function is:

$$G(x; \mu, \sigma) = \frac{1}{2}\left(\frac{x-\mu}{\sigma\sqrt{3}} + 1\right)$$

and conditions i) and ii) are met:

$$\frac{\partial Pr\{x \leq z_a\}}{\partial z_i} = \frac{\partial G(x; z_i, \sigma)}{\partial z_i} < 0$$

b) If $G = Normal(z_i, \sigma^2)$, the cumulative distribution function is:

$$G(x; \mu, \sigma) = \Phi\left(\frac{x-\mu}{\sigma}\right)$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution. Clearly, the conditions are also met:

$$\frac{\partial Pr\{x \leq z_a\}}{\partial z_i} = \frac{\partial G(x; z_i, \sigma)}{\partial z_i} = -\frac{1}{\sigma}\phi\left(\frac{x-\mu}{\sigma}\right) < 0$$

where $\phi(\cdot)$ is the standard normal density distribution.

Any of this two distributions can be used for the model.

Proof of proposition 1: Direct; derive $p^*(\lambda)$ with respect to λ. Note that this implies that $\frac{\partial p(\lambda)}{\partial \sigma_u^2} < 0$.

Proof of proposition 2: Deriving 5 with respect to γ:

$$\frac{\partial \underline{z}}{\partial \gamma} = \frac{-1}{(1-\gamma)^2} \cdot \ln(\tau) \cdot \left(\tau^{\frac{1}{\gamma-1}} + \frac{(A-B)}{Pr\{x \leq z_a\}^2 \tau (1-\gamma)}\right)^{-1}$$

Where, to save some space, we define:

$$\tau = \left(\frac{Pr\{z_a < x\}\eta - p(\lambda)\delta}{Pr\{x \leq z_a\}}\right)^{\frac{1}{1-\gamma}}$$

$$A = \frac{\partial Pr\{z_a < x\}}{\partial \underline{z}} \cdot \eta \cdot Pr\{x \leq z_a\}$$

$$B = \frac{\partial Pr\{x \leq z_a\}}{\partial \underline{z}} \cdot (Pr\{z_a < x\}\eta - p(\lambda)\delta)$$

First, note that $\ln(\tau)$ must be well defined, so we need that $Pr\{z_a < x\}\eta - p(\lambda)\delta > 0$. Next, using the probabilities conditions, we get that $A - B > 0$. Lastly, as $\eta \gg \delta$, if $Pr\{z_a < x\}\eta - p(\lambda)\delta > Pr\{x \leq z_a\}$, we get that $\tau > 1$, which results in $\ln(\tau) > 0$. This means that the expected cost of bad execution, $Pr\{z_a < x\}\eta$, is way too high and exceeds the expected cost of reverse delegating and the probability of doing the task right (right execution). This is achieved when $\eta \gg \delta$ or when there is risk of execution ($Pr\{z_a < x\} \gg Pr\{x \leq z_a\}$). Combining all, we get that

$\frac{\partial \underline{z}}{\partial \gamma} < 0$

Proof of corollary 1: Deriving 5 with respect to λ:

$$\frac{\partial \underline{z}}{\partial \lambda} = \frac{p(\lambda)}{\partial \lambda} \cdot \delta \cdot Pr\{x \leq z_a\} \cdot \left((C \cdot D)^{-1} + E - F\right)^{-1}$$

Where:

$$C = \frac{(Pr\{x \leq z_a\})^{-2}}{1-\gamma}$$

$$D = \left(\frac{Pr\{z_a < x\}\eta - p(\lambda)\delta}{Pr\{x \leq z_a\}}\right)^{\frac{\gamma}{1-\gamma}}$$

$$E = \frac{\partial Pr\{z_a < x\}}{\partial \underline{z}} Pr\{x \leq z_a\}$$

$$F = \frac{\partial Pr\{z_a < x\}}{\partial \underline{z}} \left(Pr\{z_a < x\}\eta - p(\lambda)\delta\right)$$

Using proposition 1, probabilities conditions and the same arguments used in proposition 2, we get that $\frac{\partial \underline{z}}{\partial \lambda} > 0$.

Proof of proposition 3: Given that:

$$\frac{\partial E[y]}{\partial \underline{z}} = f(\underline{z})(1-\beta-p(\lambda)\cdot(Pr\{x \leq z_a\}-\beta)) - F(\underline{z})p(\lambda)\frac{\partial Pr\{x \leq z_a\}}{\partial \underline{z}} > 0$$

And we know that $\frac{\partial \underline{z}}{\partial \gamma} < 0$, we have:

$$\frac{\partial E[y]}{\partial \gamma} = \frac{\partial E[y]}{\partial \underline{z}} \cdot \frac{\partial \underline{z}}{\partial \gamma} < 0$$

Proof of corollary 2: Deriving $E[y]$ with respect to λ, we get:

$$\frac{\partial E[y]}{\partial \lambda} = f(\underline{z})(1-\beta-p(\lambda)\cdot(Pr\{x \leq z_a\}-\beta))\frac{\partial \underline{z}}{\partial \lambda} + (F(\underline{z}) - F(z_e^a))\cdot$$

$$\left(-\frac{\partial p(\lambda)}{\partial \lambda}[Pr\{x \leq z_a\} - \beta] + (1-\beta-p(\lambda))\frac{\partial Pr\{x \leq z_a\}}{\partial \underline{z}}\frac{\partial \underline{z}}{\partial \lambda}\right)$$

Which is positive $(F(\underline{z}) - F(z_e^a) < 0)$.

Proof of proposition 4: Deriving n^* with respect to $\underline{z}$, we have:

$$\frac{\partial n^*}{\partial \underline{z}} = (1 - (1 + F(z_a^e)h))\,\frac{f(\underline{z})h}{(F(z_a^e) - F(\underline{z})h + m \cdot p(\lambda))^2} > 0$$

Using proposition 2, we get:

$$\frac{\partial n^*}{\partial \gamma} < 0$$

Proof of corollary 3: We already know that:

$$\frac{\partial n^*}{\partial \underline{z}} > 0$$

With corollary 1, we get the following:

$$\frac{\partial n^*}{\partial \underline{z}} \cdot \frac{\partial \underline{z}}{\partial \lambda} = \frac{\partial n^*}{\partial \lambda} > 0$$

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