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JEL Classification: D83, J24, J62, J63, L26, M13

Keywords: Task discretion, organizational choice, entrepreneurship, labor-market frictions, entrepreneurial failures, learning

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Task Discretion, Labor Market Frictions and Entrepreneurship*

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1 Introduction

Talent may be misallocated both within and between occupations. In this paper we study how these two types of misallocation interact, and show that the misallocation of talent within firms may cause an inefficient sorting across occupations. We do so by building a two-period model in which agents first sort between employment in a firm and entrepreneurship, and then between different ways to do a job, which we call *tasks*. An agent's productivity at different tasks, i.e., his talent, is unknown but can be learned by observing his performance at a task, with some tasks being more informative than others. However, task allocation is not contractible. As in the property right literature (Grossman and Hart, 1986), task allocation is chosen by owners or management within firms, and by the agent himself if he is an entrepreneur.

Examples of non contractible tasks informative about talent are plentiful. A contract with a scientist defines the objective of the research (e.g., find a cure for Alzheimer) but not the exact experimental design, even if the experimental design may reveal the scientist's comparative talent at following well established or unusual research paths. A contract with a new manager does not specify the exact organizational chart of the firm (people under his authority or people who have authority on him), and, as a consequence, does not specify the extent to which he can delegate or centralize decisions. Delegating or centralizing decisions may, however, reveal his comparative advantage at different styles of management.

By showing that an agent may become entrepreneur to gain task discretion and learn his talent, we bring to the literature a novel motive for entrepreneurship. This motive resembles the well-documented "be one's own boss" motive (see for example the survey by Stephan et al., 2015). Importantly, however, we do not assume that individuals have an intrinsic benefit from task discretion, from being their own boss. Becoming an entrepreneur to acquire task discretion is beneficial if and only if learning cannot occur within firms. This, in turns, depends on the level of labor market frictions which, in the model, are measured by the probability that an agent receives an external wage offer.

As this probability decreases, firms are more likely to allocate their employees to informative tasks because they capture part of the benefit of learning their workers comparative advantage. It follows that agents are less likely to become entrepreneur to gain task discretion when labor market frictions are high.

A second contribution is therefore to connect the choice between wage work and entrepreneurship with a well-known observation: that labor market frictions shape the incentives of firms to increase their workers' productivity, for example by investing in general human capital (Acemoglu and Pischke, 1999), or, in our case, by allocating workers to informative tasks. This connection sheds new light on the relationship between labor market frictions, the motives for entrepreneurship and the internal organization of firms (in terms of task discretion). In particular, in the model there is a non-monotonic relationship between the degree of labor market frictions and the likelihood of entrepreneurship. When labor market frictions are large, the main effect of a change in labor market frictions is to decrease the number of individuals who do not receive wage offers and are forced into entrepreneurship. Therefore the total number of entrepreneurs decreases when labor market frictions decrease. Instead, for small labor market frictions, because learning cannot occur within firms, the leading effect is a change in the number of people who become entrepreneur to acquire task discretion. Hence, as labor market frictions decrease, less task discretion occurs within firms, *fewer* agents are hired by firms and *more* of them will become entrepreneurs.

These comparative static results are consistent with a rough comparison of the US and the EU. By most estimates, labor-market frictions in continental Europe are significantly higher than in the USA.[1] Consistent with our theoretical mechanism, the US has a higher rate of entrepreneurship than the EU (see, for example, the Global Entrepreneurship Monitor 2015/16 Global

[1] Close to our measure of labor frictions, Ridder and Berg (2003) estimate the rate of arrival of job offers to employed workers for the US, France, UK, Germany and Holland; they show that, with the exception of the UK, European countries have a rate of job arrival that is significantly lower than in the US; Layard, Nickell, and Jackman (2005) find a similar ranking among countries when looking at the arrival rate of job offers to unemployed workers.

Report[2]) and US firms tend to give less task discretion to their workers than EU firms. Indeed, according to OECD (2013) the US ranks 14th out of 22 in terms of task discretion within firms, below most European countries.[3]

The rest of this paper proceeds as follows. The next section discusses the relevant literature. In Section 3 we introduce the model. In Section 4 we derive conditions under which the choice of task presents a trade off between learning and short-run profit maximization. We assume that this trade off is present, and derive the equilibrium of the model in Section 5. In Section 6, we present additional results relative to wages of entrepreneurs and workers along their career path and the value of entrepreneurial failures. We conclude in Section 7. Unless otherwise noted, all mathematical derivations are in Appendix A. In Appendixes B and C we relax some of our assumptions.

2 Relevant Literature

We have borrowed and also contributed to the literature on occupational choice, learning in the labor market, entrepreneurial failures and incentives for experimentation.

Co-determination of organizations and occupational choices. Our model complements those of Hellmann (2007) and De Bettignies and Chemla (2008) who focus on intellectual protection as a determinant of *innovation development* within or outside firms. When an employee owns his inventions, his incentive to innovate increases, and with it the incentive to develop this innovation as an entrepreneur, outside the firm. The firm's optimal response may be to allow the worker to develop the innovation internally as an "intrapreneur." De Bettignies and Chemla (2008) also find that as the return to entrepreneurship increases, firms become more likely to engage in corporate

[2] Available at http://www.gemconsortium.org/report/49480.

[3] In this study, the variable *task discretion* is defined, as in our model, as "Choosing or changing the sequence of job tasks, the speed of work, working hours; choosing how to do the job." The study is available at `https://read.oecd-ilibrary.org/education/oecd-skills-outlook-2013_9789264204256-en`, see in particular Figure 4.2.

venturing. We instead focus on labor-market frictions as determinant of both entrepreneurial activity and firms organizational structure.

Occupational choices and learning comparative advantages. We introduce learning agents' comparative advantages at different tasks as a driver of occupational choice. We therefore complement the literature on occupational choice started by Banerjee and Newman (1993) and Galor and Zeira (1993) that has considered financial frictions as a key determinant of career choices. Closer to our focus on learning, a literature initiated by Vereshchagina and Hopenhayn (2009) studies the choice between wage work and entrepreneurship under the assumption that the return on entrepreneurship is uncertain but can be learned. Within this literature, Manso (2016) and Dillon and Stanton (2017) show that the instantaneous payoff of entrepreneurs may be lower than that of comparable workers. This happens because entrepreneurs can always go back to wage work after having discovered that their entrepreneurial returns are low, and hence some agents are willing to "try out" entrepreneurship even if their returns are expected to be low. In our model, instead, agents learn their comparative advantage at different tasks, and by doing so increase their productivity at all possible occupations. Hence, by becoming entrepreneurs, agents do not learn their entrepreneurial ability, but rather they learn their ability *tout court*. This has novel empirical implications relative to, for example, the wage paid by firms to former entrepreneurs, which could be above or below that of former workers depending on the severity of labor-market frictions (see Section 6.1).

Talent discovery in the labor market. In pioneering papers, MacDonald (1982a,b) analyzes a task-assignment problem with symmetric uncertainty about talent, a frictionless labor market and employment as the unique occupation. Gibbons and Waldman (1999) and Gibbons and Waldman (2004) develop within-firm task assignment models in which there is learning about an agent's talent via task allocation, and also task-specific human capital accumulation. Papageorgiou (2013) studies the link between labor-market frictions and talent discovery. His model assumes that firms use only one task, hence cannot choose their internal organization. In his framework, agents must move *between* firms to discover their comparative advantage. Hence, as labor-market frictions increase, mobility decreases and the rate of talent discovery must decrease. This is not always true in our model because agents can learn *within* firms, and more severe labor-market frictions enhance learning in firms.

Pastorino (2019) estimates a labor market model in which firms generate information about their workers via task assignment, and measures the importance of learning relative to human capital accumulation in explaining cumulative wage growth and wage dispersion. Antonovics and Golan (2012) address experimentation, defined as choosing a job where the expected probability of success is low, but where the agent's type correlates with outcome. Terviö (2009) argues that cash constraints or the absence of long-term contracting prevent optimal talent discovery, in the sense that jobs will not reveal productivity of the worker. In Canidio and Gall (2019) the rate of on-the-job talent discovery depends on the task allocation chosen within firms, which may be inefficient.

While there are some important connections with all these papers, none of them allow agents to change occupation, to become entrepreneurs.

Value of failures. It is a common assumption in the economic literature that failures provide bad news about the expected productivity of an agent. Prominent examples in the literature on entrepreneurship are Gromb and Scharfstein (2002) and Landier (2005), who build equilibrium models in which entrepreneurial failures always produce a stigma, which may be more or less pronounced depending on some features of the economy. In Gromb and Scharfstein (2002), failed entrepreneurs are hired by firms. Because of exogenous noise, failing in a start-up is not as bad a signal as being fired as a manager, and firms will replace failed managers with failed entrepreneurs. Landier (2005) shows that when failures are widespread, they reveal little information regarding the entrepreneur's type and hence there is a high level of entrepreneurship. When failures are rare, they carry a larger stigma and deters entrepreneurship.[4]

Many business leaders and scholars share Henry Ford's view that a failure "is only the opportunity to begin again more intelligently." For example, the *Harvard Business Review* dedicated an entire issues to failures and how they led to business success ("Failure Chronicles," April 2011). A recent book by the journalist Tim Harford, *Adapt: Why Success Always Starts with Failure* well summarizes this positive attitude in the business world toward entrepreneurial failures.

Our model shows how the value of entrepreneurial failures reflects the *nature of talent*. Talent can be *horizontal*–different agents have an absolute advantage at different tasks—or vertical *vertical*– same agents have an absolute advantage at all tasks. Then, talent can be good news or bad news depending on the level of labor market frictions only if talent is horizontal. If instead talent is vertical, failures are always bad news. As we will see, current evidence provides support to the horizontal view.

Experimentation and incentives. The literature on experimentation and incentives (Jeitschko and Mirman, 2002; Manso, 2011; Drugov and Macchiavello, 2014; Gomes, Gottlieb, and Maestri, 2016) focuses on how to design a contract that motivates *an agent* to experiment. By contrast, in our model the choice of task allocation (and therefore of whether to engage in learning) rests with the firm. We will therefore study how to design a contract that motivates *a firm* to experiment.

Finally, at the core of our model there is a tradeoff between short-run profit maximization and learning. This tradeoff has been extensively studied by the literature on multi-arms bandit problems, and is therefore neither new nor specific to our model. However, this literature typically assumes that the arms are independent: success and failures at an arm is not informative with respect to the other arm. Hence, failures always reduce the probability of future success. This case is therefore equivalent to the vertical talent case.

[4] See also Schumacher, Gerling, and Kowalik (2015).

3 The model

The economy is composed of a finite set of risk-neutral agents and a finite set of at least two firms that compete for workers. Agents live for two periods $t \in \{1, 2\}$, and can be of type $\theta \in \{l, h\}$, where l stands for low and h for high. Agents' types are *not* observable by agents or firms. The common initial belief about a young agent's type is $\text{pr}\{\theta = h\} = p_1$.

Production and returns. In period t there is an "off-the-shelf" technology accessible to all firms. Each worker employed in a firm generates a monetary return K_t when she succeeds and 0 when she fails (this is independent of the number of workers in the firm.) We assume that K_t is drawn at the beginning of each period from the uniform distribution on $[0, 2]$, hence that the aggregate shocks determining K_t are uncorrelated across periods and hence the returns K_1, K_2 are independent.

In period t, each agent gets an idea about a project k_t. The aggregate shocks determining K_t also affect an agent's specific k_t, and we assume that each k_t is drawn from the uniform distribution on $[0, \lambda K_t]$, where $\lambda \geq 1$. (Hence, k_t is drawn independently over time and across agents.) For instance, for a given off-the-shelf technology K_t available to firms, some individuals realize that they can improve on this technology if they leave the firm to become an entrepreneur (in which case $k_t > K_t$) while others realize that they will not be able to replicate perfectly the returns that this technology allows within a firm (in which case $k_t < K_t$). If the agent becomes an entrepreneur, he can pursue this project and generate a monetary return k_t in case of success.

In each period t, an agent can work either in a firm or as an entrepreneur. In both cases, he can work either on an Advanced task ($\tau_t = A$) or a Basic task ($\tau_t = B$), and may fail ($s_t = 0$) or succeed ($s_t = 1$). The probability of success depends on the agent's type and the task chosen:[5]

$\tau \backslash \theta$	l	h
B	l_B	h_B
A	l_A	h_A

When each agent is assigned to the task at which he is the most likely to succeed, high types have an advantage over low types:

$$\max(h_A, h_B) \geq \max(l_A, l_B). \tag{1}$$

To avoid trivialities, we assume that individuals have different comparative advantages, high types being better at the advanced task while low types being better at basic tasks:[6]

$$h_A - h_B > 0, \ l_B - l_A > 0. \tag{2}$$

For instance, some agents may excel at finding creative solutions to a new problem but will be unproductive at following strict orders; others flourish and can be creative in a team environment but will be low performers in isolation. The environment described in (1)-(2) is a discrete version of MacDonald (1982a,b) and is consistent with two visions of talent.

- (**Vertical talent**) If $h_B \geq l_B$ the probabilities of success at both tasks are at least as large for type h than type l. Hence types can be ranked in terms of productivity. High types have an absolute advantage over low types: they have higher "quality" independently of the task they

[5] Note that the specification allows for a task to be uninformative (for instance $l_B = h_B$). In a previous version of the model we considered the possibility of a third type of agent who is "bad" at all tasks but this extension complicated the analysis without bringing additional insights (if there is a minimum productivity threshold for an agent to be hired, then some agents may be unemployable, but otherwise the task allocation problem of employable agents is the same as in the current specification).

[6] If this is not the case, there is a task that maximizes the probability of success of each type, and no firm or entrepreneur will use the other task since learning has no value for task allocation.

are working on. This is the usual interpretation of talent as a vertical dimension.

- (**Horizontal talent**) When $h_B < l_B$, high type agents have a larger probability of success only if assigned to the advanced task A. Otherwise, if assigned to the basic task, a high type agent is in fact less successful than a low type agent. Talent is *horizontal* rather than vertical, and it is not possible to rank types in terms of productivity unless the task assignment is defined.

Contract offers. We restrict attention to short-term contracts. In every period, a contract consists of a fixed payment f and a bonus payment b contingent on success. We make the following additional assumptions on the contracting environment.

Assumption 1.

(i) *Output is not fully contractible and the bonus is strictly bounded above by the monetary return of the firm, that is* $b \leq \beta K_t$ *where* $\beta < 1$.

(ii) *Task allocations within firms are observable but not contractible.*

We interpret the parameter β in (i) as an index of contract completeness. Within a firm, the value of a success is K_t, but contracts can be contingent only on βK_t. For instance, if the owners of the firm can "run away" and capture a proportion $1 - \beta$ of the monetary return, bonus payments with a share of monetary returns greater than β are not incentive compatible. Because $\beta < 1$ a worker and a firm cannot sign a contract that leaves the firm completely indifferent between success or failure.

The second part (ii) of the assumption implies that contracts cannot be made contingent on task allocation. This is consistent with the modern literature on delegation which emphasizes that ownership restricts the ability not to interfere with other agents' decisions, in particular in the context of the delegation of tasks (Aghion and Tirole, 1997; Baker et al., 1999). Of course, in a specification of the model with more than two tasks, it may be possible to contract over sets of tasks (for example, different sets of task may require different locations, and location may be contractible). Such an extension would not change our results, provided that the contract has fewer contingencies than the number of tasks.

Our restrictions to short-term contracts and observable task allocations simplify the analysis but are not essential. In Appendix B we consider the case of unobserved task allocation, and show that our results hold in this case as well. In Appendix C we introduce the possibility of using long-term contracts. Not surprisingly, long-term contracts improve the value of entering in an employment relationship. However, they do not eliminate the probability that an agent becomes an entrepreneur to learn his type. It follows that our results hold qualitatively in that case as well.

Labor-market frictions. We introduce labor-market frictions in a stark way by assuming that with probability $1-\alpha$ an agent receives no offer from firms, and with probability α he receives at least two offers. This would be the case for instance if there is a central place where all vacancies are posted and an agent has access to an imperfect search technology.[7]

Timing The main differences between the two periods is the possibility of continuing an employment relationship. In period $t = 1, 2$, the timing is the following:

(1) K_t (the same for all firms) and k_t (i.i.d. among agents) are realized.

(2) All firms simultaneously offer contracts to all agents.

(3) **If $\mathbf{t = 1}$**: agents who receive an employment offer choose between entrepreneurship and employment. Agents who do not receive an employment offer become entrepreneurs.

[7] Hence there is a zero probability of receiving a single offer. If the probability of an agent's receiving a single offer is positive, firms can design their contracts knowing that, with a small probability, they might have monopsony power over the agent. This significantly complicates the firm's problem but does not modify our qualitative results.

If t = 2: Agents who receive a wage offer choose between entrepreneurship and employment. Former entrepreneurs who do not receive a wage offer remain entrepreneurs. Former workers who do not receive a wage offer can continue working for their former employers, in which case the surplus generated by continuing the employment relationship is split via Nash bargaining.[8]

(4) After a contract is signed, the firm chooses the worker's task. Entrepreneurs choose their own task.

(5) Outcomes (success or failure) are realized and observed by everybody. In the case of success, a firm's output is K_t, while an entrepreneur's output is k_t.

4 When Learning Conflicts with Short-Term Return Maximization

In this section we derive conditions under which there is a conflict in period-1 between the task allocation maximizing the present probability of success and the task allocation maximizing the future expected probability of success. These conditions are necessary for a meaningful tradeoff between learning and short-run profit maximization to emerge. The reader interested in the equilibrium analysis for occupational choice and wage setting could go directly to section 5 below.

For any prior belief p_t that the individual is of type h, the probability that there is a success in a given period is:

$$\pi(\tau_t, p_t) \equiv \begin{cases} (1-p_t)\cdot l_A + p_t \cdot h_A & \text{if } \tau_t = A \\ (1-p_t)\cdot l_B + p_t \cdot h_B & \text{if } \tau_t = B. \end{cases}$$

It follows that the probability of success in the current period is maximized by

[8] Nash bargaining is assumed for simplicity. All our results are robust to other assumptions, provided that some of the surplus generated by continuing the employment relationship is captured by the firm.

assigning the agent to task B if and only if p_t is smaller than the cutoff value

$$q^* \equiv \left(1 + \frac{h_A - h_B}{l_B - l_A}\right)^{-1}, \tag{3}$$

Call $\pi^M(p_t)$ the maximum probability of success in a given period, defined as

$$\pi^M(p_t) \equiv \max_{\tau_t} \pi(\tau_t, p_t) = \begin{cases} (1-p_t)l_B + p_t h_B & \text{if } p_t \leq q^* \\ (1-p_t)l_A + p_t h_A & \text{if } p_t \geq q^*, \end{cases} \tag{4}$$

that is, the probability of instantaneous success assuming that the agent is allocated to the task with the largest probability of success. Because period 2 is the last period of the game, in that period both entrepreneurs and firms choose the task allocation that maximizes the instantaneous probability of success, and therefore $\pi^M(p_2)$ is the *equilibrium* probability of success in period 2 for given p_2.

We define the period-1 probability of success as $\sigma_1(\tau_1) \equiv \pi(\tau_1, p_1)$, that is the probability of instantaneous success at the initial belief p_1. Without loss of generality, we assume that task B is the short-term output maximizing task.

Assumption 2. $p_1 < q^*$*: task* B *maximizes the initial probability of success, that is* $\sigma_1(B) > \sigma_1(A)$*.*

We are interested in establishing conditions under which $\tau_1 = A$ maximizes the *period-2* expected probability of success. The posterior belief given a task allocation τ_1 in the first period and whether there is success ($s_1 = 1$) or failure ($s_1 = 0$) at the end of period 1 is:

$$p_2(\tau_1, s_1) \equiv \begin{cases} \left(\frac{1-p_1}{p_1}\frac{l_{\tau_1}}{h_{\tau_1}} + 1\right)^{-1} & \text{if } s_1 = 1 \\ \left(\frac{1-p_1}{p_1}\frac{1-l_{\tau_1}}{1-h_{\tau_1}} + 1\right)^{-1} & \text{if } s_1 = 0 \end{cases}$$

Comparing two posteriors is therefore equivalent to comparing the likelihood of facing a high type: for instance, $p_2(\tau_1, 1) > p_2(\tau_1, 0)$ if, and only if, the likelihood of facing a high type is greater after a success than after a failure: $\frac{h_{\tau_1}}{l_{\tau_1}} > \frac{1-h_{\tau_1}}{1-l_{\tau_1}}$.

From period 1's point of view, choosing task τ_1 yields in period 2 an expected probability of success equal to:

$$\sigma_2(\tau_1) \equiv \mathbb{E}_{s_1 \in \{0,1\}} \pi^M(p_2(\tau_1, s_1)),$$

The next propositions provide conditions under which A is (strictly) more informative than B, that is $\sigma_2(A) > \sigma_2(B)$.

Proposition 1. *In the vertical talent case there is a conflict between maximizing today's probability of success and tomorrow's if and only if*

$$p_1 > \left(1 + \frac{h_A}{l_A}\frac{h_A - h_B}{l_B - l_A}\right)^{-1}.$$

In the horizontal talent case there is a conflict between maximizing today's probability of success and tomorrow's if:

$$p_1 > \left(1 + \frac{h_A}{l_A}\frac{h_A - h_B}{l_B - l_A}\right)^{-1} \quad \textit{and} \;\; h_A - l_A > l_B \cdot h_A - l_A \cdot h_B > l_B - h_B.$$

Note that the above proposition provides necessary and sufficient conditions for the vertical talent case, but only sufficient conditions for the horizontal talent case. We give in Proposition 4 in the Appendix the necessary and sufficient conditions for $\sigma_2(A) > \sigma_2(B)$ for the horizontal talent case. Figure 1 below illustrates a typical tradeoff between period-1 opportunity cost $\sigma_1(B) - \sigma_1(A)$ and period-2 gain $\sigma_2(A) - \sigma_2(B)$ from choosing $\tau_1 = A$ instead of $\tau_1 = B$.[9]

Having established the possibility of a conflict in period 1 between instantaneous success and learning, we now analyze how this conflict influences career choices and returns from these choices. We will take as given that $\sigma_1(A) < \sigma_1(B)$ and that $\sigma_2(A) > \sigma_2(B)$.

[9] The units have been rescaled; the intersection of the two curves is at $p < 5/11$, that is when task B is always chosen in the second period if task B is chosen in the first period. Horizontal talent leads to similar looking curves.

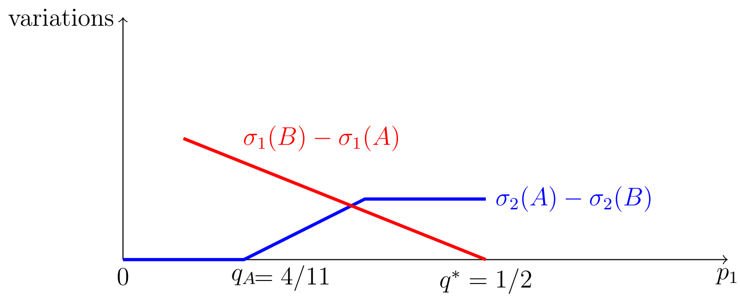


Fig. 1: Vertical talent example: $h_A = 0.7$; $h_B = 0.6$; $l_B = 0.5$; $l_A = 0.4$

5 Equilibrium Analysis

In the first subsection we derive the lifetime value of starting a career as a worker or as an entrepreneurs, as a function of k_1, K_1 and α. In the next subsection, we solve for the choice of occupation, taking into account that some agents may not receive wage offers.

5.1 Value Functions

Period 2 payoffs. In period 2, if an agent accepts a job offer he earns the full expected return of the firms' project,[10] which implies that the choice of becoming an entrepreneur or employee depends on what project is more valuable. Hence, from period-1 point of view, the expected period-2 payoff conditional on receiving an employment offer (which happens with probability α) is[11]

$$\sigma_2(\tau_1) \cdot \mathbb{E}[\max\{k_2, K_2\}] = \sigma_2(\tau_1) \cdot \frac{1}{2}\left(\lambda + \frac{1}{\lambda}\right).$$

Note that the above expression depends on period-1 task allocation via the probability of period-2 success.

When an agent does not receive offers (which happens with probability $1 - \alpha$), his period-2 payoff depends not only on his period-1 task allocation

[10] Because period 2 is the last period of the game, firms and workers have the same preferences over task allocation: they prefer the task allocation that maximizes period-2 output. Hence, the exact structure of a period-2 contract (that is, what part is paid as bonus b and what part is paid as fixed wage f) is not relevant.

[11] The calculations omitted from the text are in Appendix, page 39.

but also on his period-1 occupation. A period-1 entrepreneur remains an entrepreneur in period-2 whenever he does not receive a wage offer in period-2, and therefore earns k_2 in case of success. Hence, the expected period-2 payoff of a period-1 entrepreneur is:

$$\sigma_2(\tau_1)\left(\alpha\mathbb{E}[\max(k_2,K_2)]+(1-\alpha)\mathbb{E}[k_2]\right)=\sigma_2(\tau_1)\left(\frac{\alpha}{2}\left(\lambda+\frac{1}{\lambda}\right)+(1-\alpha)\frac{\lambda}{2}\right),$$

which is increasing in α. Instead, a period-1 employee who does not receive wage offers can continue working for his period-1 employer. In this case, the agent and his period-1 employer need to split a surplus given by the difference between the value of continuing the employment relationship and the value of entrepreneurship, that is $\sigma_2(\tau_1)\max\{K_2-k_2,0\}$, where $\mathbb{E}[\max\{K_2-k_2,0\}]=\frac{1}{2\lambda}$. Hence, from period 1 point of view, each firm earns a period-2 expected profit equal to

$$(1-\alpha)\sigma_2(\tau_1)\mathbb{E}\left[\frac{1}{2}\max\{K_2-k_2,0\}\right]=\sigma_2(\tau_1)\frac{1-\alpha}{4\lambda}.$$

These profits are decreasing in α and, crucially, for $\alpha<1$ are larger when $\tau_1=A$ than when $\tau_1=B$. That is, because of labor market frictions, in period 2 firms may be able to earn part of the benefit of learning their workers' talent. Similarly, from period 1 point of view, the expected period-2 payoff of a period-1 worker is:

$$\begin{aligned}&\sigma_2(\tau_1)\left(\alpha\mathbb{E}[\max(k_2,K_2)]+(1-\alpha)\mathbb{E}\left[k_2+\frac{1}{2}\max\{K_2-k_2,0\}\right]\right)\\&=\sigma_2(\tau_1)\left(\frac{\alpha}{2}\left(\lambda+\frac{1}{\lambda}\right)+\frac{5(1-\alpha)}{4\lambda}\right)\end{aligned}$$

We now compute to value of choosing a given occupation in period-1 by solving for the optimal period-1 task allocation.

Lifetime utility of a period-1 entrepreneur. The expected period-1 payoff of an entrepreneur is $\sigma_1(\tau_1)\cdot k_1$. Hence, task τ_1 generates an expected return over the two periods equal to

$$\sigma_1(\tau_1)k_1 + \sigma_2(\tau_1)\left(\frac{\alpha}{2}\left(\lambda + \frac{1}{\lambda}\right) + (1-\alpha)\frac{\lambda}{2}\right).$$

An entrepreneur chooses $\tau_1 = A$ whenever

$$k_1 \leq k^A(\alpha) \equiv \frac{\alpha + \lambda^2}{2\lambda} \times \frac{\sigma_2(A) - \sigma_2(B)}{\sigma_1(B) - \sigma_1(A)}, \tag{5}$$

That is, the entrepreneur will favor learning over short-run profits whenever the current value of a success is low relative to the future expected value of a success. Higher labor market frictions (i.e., lower α) reduce the probability that the agent will receive a wage offer and that he will work for a firm when $K_2 > k_2$. Hence, from the point of view of period-1, as labor-market frictions become more severe the value of a period-2 success decreases, learning becomes less valuable, and the entrepreneur is more likely to choose task B.

Finally, the lifetime utility of a period-1 entrepreneur is:

$$W^E(k_1, \alpha) = \begin{cases} \sigma_1(A)k_1 + \sigma_2(A)\frac{\alpha+\lambda^2}{2\lambda} & \text{if } k_1 \leq k^A(\alpha) \\ \sigma_1(B)k_1 + \sigma_2(B)\frac{\alpha+\lambda^2}{2\lambda} & \text{if } k_1 > k^A(\alpha), \end{cases}$$

which is continuous and strictly increasing in both arguments.

Lifetime utility of a period-1 worker. The total output generated within a firm is

$$\sigma_1(\tau_1)K_1 + \sigma_2(\tau_1)\frac{\lambda^2 + 1}{2\lambda}.$$

This expression is also equivalent to the total output generated by an entrepreneur with project $k_1 = K_1$ in the absence of labor market frictions (that is, when $\alpha = 1$). It follows that the two period total output generated within firms is maximized by task A if, and only if, $K_1 \leq k^A(1)$, where $k^A(1)$ is defined in (5).

However, the output maximizing task allocation may not be incentive compatible. Remember that firms earn zero profits in equilibrium and therefore the period-2 profits that a period-1 employer expects to earn in case its employee does not receive an outside wage offer are factored into the period-1 contract offered to the worker. However these period-2 profits are relevant in deriving the period-1 task allocation. After a contract (f, b) is signed in period 1, the fixed component f is sunk and the determinants of the optimal task choice are the bonus b and the expected period-2 profits. Choosing task A generates a period-1 opportunity cost equal to $(\sigma_1(B) - \sigma_1(A))(K - b)$, a decreasing function of b. By contrast the *future* benefit of choosing task A in the first period is $(\sigma_2(A) - \sigma_2(B))\frac{1-\alpha}{4\lambda}$, that is the expected value of the share of surplus accruing to the firm in case its worker does not receive a wage offer.

Because, by assumption, the largest possible bonus b is $b = \beta K_1$, the firm can commit to implement task A in the first period if $(\sigma_1(B) - \sigma_1(A))(1 - \beta)K_1 \leq (\sigma_2(A) - \sigma_2(B))\frac{1-\alpha}{4\lambda}$, that is when

$$K_1 \leq K^A(\alpha) \equiv \frac{1-\alpha}{4\lambda(1-\beta)} \times \frac{\sigma_2(A) - \sigma_2(B)}{\sigma_1(B) - \sigma_1(A)}. \tag{6}$$

Since the smallest possible bonus is zero, the firm can commit to implement task B if $(\sigma_1(B) - \sigma_1(A))K_1 \geq (\sigma_2(A) - \sigma_2(B))\frac{1-\alpha}{4\lambda}$, that is when

$$K_1 \geq K^B(\alpha) \equiv \frac{1-\alpha}{4\lambda} \times \frac{\sigma_2(A) - \sigma_2(B)}{\sigma_1(B) - \sigma_1(A)}.$$

Clearly, for any α, $K^B(\alpha) < k^A(1)$ and the firm can always implement task B whenever it is output maximizing to do so.

A sufficiently large bonus b, therefore, serves as a commitment to implement the most informative task (task A). The observation that larger bonuses can generate more learning contrasts with that of Manso (2011) who argues that a principal may motivate a worker to experiment by paying a fixed wage initially and a large bonus for success far in the future. The reason for this contrast is that in Manso (2011) the choice of learning rests with the worker while in our model the choice of learning via task allocation rests with the firm. Hence if a large bonus is paid to the worker, the firm's payoff is less sensitive to the realization of failures and success and therefore the firm is more likely to choose the learning-maximizing task allocation.

Competition for workers among firms allows us to reduce the firm's problem to the choice of a task τ_1 that maximizes the two-period total output subject to the incentive compatibility constraints, that is:

$$W^F(K_1,\alpha) \equiv \max_{\tau_1=A,B} \sigma_1(\tau_1)K_1 + \sigma_2(\tau_1)\frac{1+\lambda^2}{2\lambda}$$
$$\tau_1 = A \Rightarrow K_1 \leq K^A(\alpha).$$

By observing that the incentive compatibility constraint is binding if and only if $K^A(\alpha) < k^A(1)$ we arrive at the following lemma:

Lemma 1. *(i) In a competitive equilibrium, firms choose contracts that implement task $\tau_1 = A$ if $K_1 \leq \min\{K^A(\alpha), k^A(1)\}$ and task $\tau_1 = B$ otherwise.*

(ii) Whenever $K_1 \geq k^A(1)$ or $K_1 \leq K^A(\alpha)$ the equilibrium task allocation maximizes the two-period total output. Whenever $K_1 \in (K^A(\alpha), k^A(1))$ the firm's task allocation is inefficient: the two-period total output is maximized by $\tau_1 = A$ but firms implement $\tau_1 = B$.

Proof. In the text. □

Figure 2 provides a graphical illustration of the lemma. If α is sufficiently low, then for a given K_1 the firm allocates the worker to the task that maximizes the two-period total output. In particular, the firm sets $\tau_1 = A$ whenever K_1 is below $k^A(1)$ and $\tau_1 = B$ otherwise. If instead α is high, there is a range of K_1 for which it would be optimal to implement $\tau_1 = A$, but no contract can achieve it. In this case, for low K_1 the firm maximizes the two-period total output by setting $\tau_1 = A$, for high K_1 the firm maximizes two-period total output by setting $\tau_1 = B$, for intermediate K_1 the firm sets $\tau_1 = B$ despite the fact that $\tau_1 = A$ generates higher two-period total output. For every α, the size of this last region depends on the degree of contract incompleteness β. In particular, for higher β (i.e., a large fraction of output is contractible) the firm is able to pay larger bonuses, and is therefore more likely to maximize the

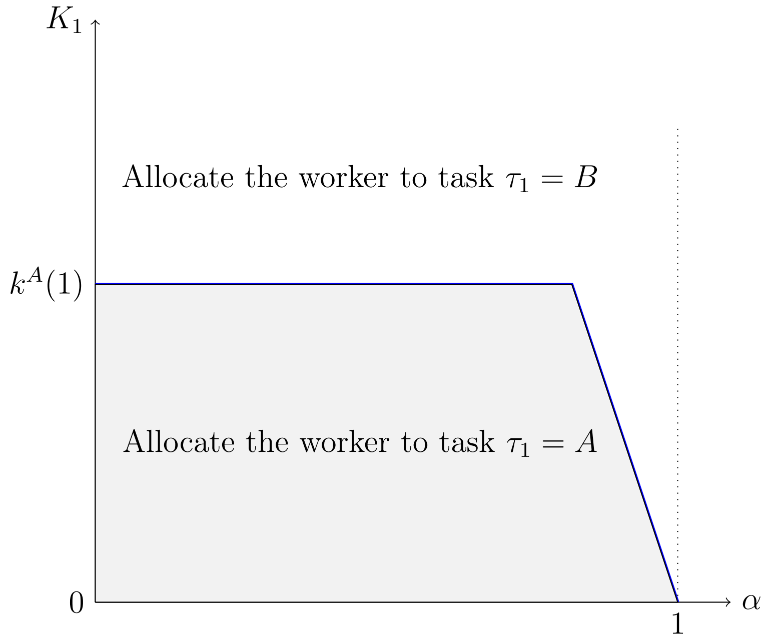


Fig. 2: Period 1 task allocation within firms.

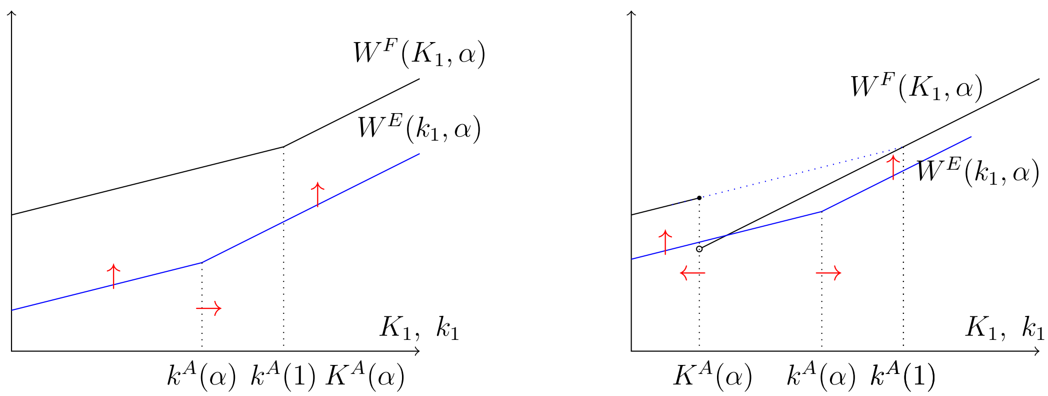
two-period total output. The opposite holds for low β (i.e., a large fraction of output not contractible).

Hence, the inability of firms to commit to a task allocation makes them short-termists when $K_1 \in (K^A(\alpha), k^A(1))$, which is more likely to happen when labor market frictions are low (i.e., α is high). When there are no labor market frictions ($\alpha = 1$), firms always implement the short-run output maximizing task allocation, and learning cannot occur within firms.

5.2 Equilibrium Occupational Choices

Having derived the value of being a period-1 worker or a period-1 entrepreneur, we now close the model by solving for the optimal period-1 occupational choice.

In period 1, a fraction $1 - \alpha$ of agents do not receive a wage offer and therefore become entrepreneurs. We call these agents *necessity entrepreneurs*. The agents who receive a wage offer will choose their occupation by comparing the two period payoff earned as an entrepreneur with two period payoff earned as a worker. Figure 3 plots these payoffs as a function of K_1 and k_1 when α is small and large; the red arrows indicate the change in the curves when α increases.



(a) Low α: $K^A(\alpha) > k^A(1)$

(b) High α: $K^A(\alpha) < k^A(1)$

Fig. 3: Payoffs and labor market frictions.

The discontinuity in $W^F(K_1, \alpha)$ for high values of α illustrates the incentive problem faced by the firm in choosing task allocation. As α increases workers are more likely to receive competing offers, and firms will assign workers more often (that is for a large set of K_1) to the basic task. This assignment is inefficient for $K_1 < k^A(1)$ but maximizes short-run profits. The discontinuity arises at $K^A(\alpha)$, which is the value of K_1 at which the firm is indifferent between assigning the worker to either task. At this cutoff the firm can credibly commit to assign the worker to the advanced task, leading to an upward jump in the value of working for a firm whenever the advanced task is the efficient one, that is, at $K_1 = K^A(\alpha)$. Because $K^A(\alpha)$ is decreasing in α, the expected two-period payoff from employment also decreases in α. At the same time, $W^E(k_1, \alpha)$ increases with α. Therefore, *ceteris paribus* as α increases agents are more likely to choose entrepreneurship when they obtain a wage offer.

Formally, an agent who receives a wage offer will become an entrepreneur whenever

$$W^E(k_1, \alpha) \geq W^F(K_1, \alpha)$$

We denote by $k^E(K_1, \alpha)$ the project value k_1 leaving an agent indifferent between becoming an entrepreneur and working for a firm:

$$k^E(K_1, \alpha) \equiv k_1 \text{ solution to } W^E(k_1, \alpha) = W^F(K_1, \alpha).$$

Note that the payoff earned from working for a firm can be rewritten as:

$$\begin{aligned} W^F(K_1, \alpha) = & \max_{\tau_1 \in \{A,B\}} \left\{ \sigma_1(\tau_1) K_1 + \sigma_2(\tau_1) \left(\frac{1}{2} \left(\lambda + \frac{1}{\lambda} \right) \right) \right\} \\ & - \mathbb{1} \left\{ K_1 \in [K^A(\alpha), k^A(1)] \right\} \left((\sigma_1(A) - \sigma(B)) K_1 + (\sigma_2(A) - \sigma_2(B)) \frac{1+\lambda^2}{2\lambda} \right), \end{aligned}$$

that is, total output assuming that the task allocation implemented within firms is optimal, minus a loss whenever learning cannot occur within firms, which is realized whenever $K_1 \in [K^A(\alpha), k^A(1)]$. Given this, we can categorize the mass of agents who become entrepreneurs after receiving a wage offer into two groups:

- *Opportunity entrepreneurs*: These agents prefer entrepreneurship to working for a firm for any task they may be allocated to within the firm. In other words, these agents have a project value k_1 larger than

  $$k^O(K_1, \alpha) \equiv k_1 : \; W^E(k_1, \alpha) = \max_{\tau_1 \in \{A,B\}} \left\{ \sigma_1(\tau_1) K_1 + \sigma_2(\tau_1) \frac{1+\lambda^2}{2\lambda} \right\},$$

  where the RHS is the *maximum* two period output generated within a firm. Note that, by definition, $k^O(K_1, \alpha)$ is decreasing in α and increasing in K_1. Furthermore $k^O(\alpha, K_1) > K_1$ for $\alpha < 1$ and $k^O(\alpha, K_1) = K_1$ for $\alpha = 1$. Hence, opportunity entrepreneurs always work on projects of value higher of that of firms.

- *Learning entrepreneurs*: those for which $k_1 \in [k^E(K_1, \alpha), k^O(K_1, \alpha)]$. These agents become entrepreneurs because firms implement task $\tau_1 = B$ despite the fact that task $\tau_1 = A$ maximizes the two period output. These entrepreneurs will implement task $\tau_1 = A$. In other words, these agents become entrepreneurs to choose the learning-maximizing task whenever this cannot happen within firms.

We can therefore decompose the probability of becoming an entrepreneur in period 1 into three elements corresponding to the three motives:

$$P_1^E(\alpha) \equiv \underbrace{(1-\alpha)}_{\text{necessity}} + \underbrace{\alpha \cdot \text{pr}\{k_1 > k^O(K_1,\alpha)\}}_{\text{opportunity}} + \underbrace{\alpha \cdot \text{pr}\{k^E(K_1,\alpha) < k_1 < k^O(K_1,\alpha)\}}_{\text{learning}}$$
$$= 1 - \alpha + \alpha \cdot \text{pr}\{k_1 > k^E(K_1,\alpha)\}.$$

Whenever α is sufficiently low $K^A(\alpha) > k^A(1)$ and the task allocation within firms is optimal; therefore there are no learning entrepreneurs. This is apparent from the left panel in Figure 3 since for any value of K_1, individuals who become entrepreneurs while receiving offers are more likely to use the basic task. Instead, whenever α is sufficiently high $K^A(\alpha) < k^A(1)$ and the task allocation within firms may not be optimal; in this case, there is a positive probability of being a learning entrepreneur. For instance, in the right panel of Figure 3, at the intersection of W^F and W^E (that is, when the agent gets the same project as the firm) he will choose task A as an entrepreneur while the firm would choose task B. Similarly, the probability of becoming an opportunity entrepreneur is zero whenever $k^O(K_1,\alpha) > \lambda K_1$ which happens whenever either λ or α is sufficiently low, and is strictly positive otherwise.

The level of labor market frictions therefore affects both the probability of becoming an entrepreneur in period 1, and the importance of the different motives for entrepreneurship. This is illustrated by Figure 4, in which we report a numerical simulation. Note that the learning motive becomes relatively more important with respect to the other motives when α is large, generating in this simulation a U-shape relationship between α and the probability of becoming an entrepreneur in period 1. The following lemma shows that, in general, there is a non-monotonic relationship between labor market frictions and the probability of becoming an entrepreneur: as α is close to zero, the first order effect is the decrease in necessity entrepreneurs while when α is close to 1 the first order effect is the increase in learning entrepreneurs.

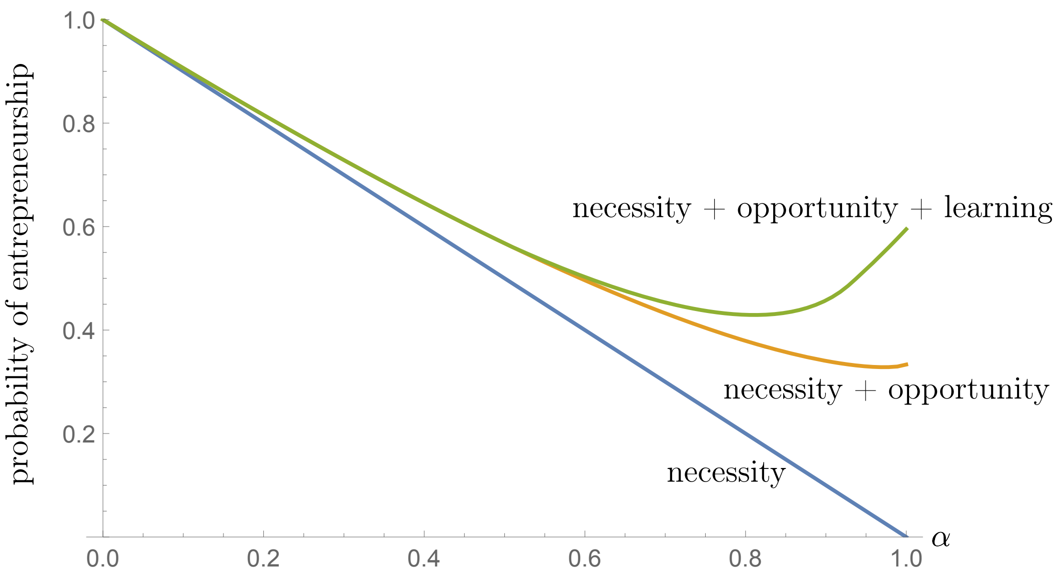


Fig. 4: Motives for Entrepreneurship as a function of α ($\beta = 0.9$, $\lambda = 1.5$, $p = 0.45$, $h_A = 0.9$, $l_A = 0.1$, $h_B = 0.4$, $l_B = 0.6$)

Lemma 2. *The probability of first period entrepreneurs $P_1^E(\alpha)$ is decreasing for α close to 0 and increasing for α close to 1.*

In period 2, instead there is no value of learning and hence there are no "learning entrepreneurs". All those who previously worked for a firm become entrepreneurs if $k_2 > K_2$ and continue working for a firm otherwise. Similarly, all former entrepreneurs who receive a wage offer choose entrepreneurship if and only if $k_2 > K_2$. Instead, former entrepreneurs who do not receive a wage offer are again entrepreneurs. The probability of becoming an entrepreneur in period 2 is therefore:

$$\begin{aligned} P_2^E(\alpha) &\equiv (1-\alpha)P_1^E(\alpha) + (1-(1-\alpha)P_1^E(\alpha))\text{pr}\{k_2 > K_2\} \\ &= (1-\alpha)P_1^E(\alpha)(1-\text{pr}\{k_2 > K_2\}) + \text{pr}\{k_2 > K_2\} \end{aligned}$$

Having derived $P_1^E(\alpha)$ and $P_2^E(\alpha)$, we can now compute two commonly used measures of aggregate entrepreneurial activity: the probability of being a serial entrepreneur and the average probability of becoming an entrepreneur across periods.[12] The probability of being a serial entrepreneur (that is, an entrepreneur in both periods) is

$$P^E_{\text{serial}}(\alpha) \equiv P^E_1(\alpha) \cdot (1 - \alpha + \alpha \cdot \text{pr}\{k_2 > K_2\}),$$

and the average probability of becoming an entrepreneur across periods:

$$\begin{aligned} P^E_{(1/2)}(\alpha) &\equiv \frac{1}{2}\left(P^E_1(\alpha) + P^E_2(\alpha)\right) \\ &= \frac{1}{2}\left(P^E_1(\alpha)(1 + (1-\alpha)(1 - \text{pr}\{k_2 > K_2\})) + \text{pr}\{k_2 > K_2\}\right). \end{aligned}$$

As the next proposition shows, if the learning motive for entrepreneurship is sufficiently strong, entrepreneurial activity increases in α. This implies the rather surprising result that, as labor market frictions are reduced, *fewer* people become workers.

Proposition 2. *$P^E_{serial}(\alpha)$ and $P^E_{(1/2)}(\alpha)$ are decreasing for α close to 0, and increasing for α close to 1 if*

$$\frac{\sigma_2(A) - \sigma_2(B)}{\sigma_1(B) - \sigma_1(A)} > \frac{4\lambda^2(1-\beta)}{\lambda - 1} \tag{7}$$

The LHS of the above expression measures the value of learning one comparative advantage relative to its cost. On the RHS, β measures the firm's ability to internalize the benefit of learning. When either $\frac{\sigma_2(A)-\sigma_2(B)}{\sigma_1(B)-\sigma_1(A)}$ or β is large, a small amount of labor market frictions allow firms to internalize the benefit of learning. However, as labor market frictions disappear, learning cannot happen within firms. It follows that under (7) the fraction of learning entrepreneurs reacts very rapidly to changes in α, therefore determining the shape of $P^E_{\text{serial}}(\alpha)$, and $P^E_{(1/2)}(\alpha)$.

Using the same parameter values as in Figure 4, a simulation shows indeed a non-monotonic relationship between α and these two aggregate measures of entrepreneurship (see Figure 5).

[12] In an overlapping generation extension of the model, $P_{(1/2)}$ is the probability that, at any given moment in time an agent is an entrepreneur.

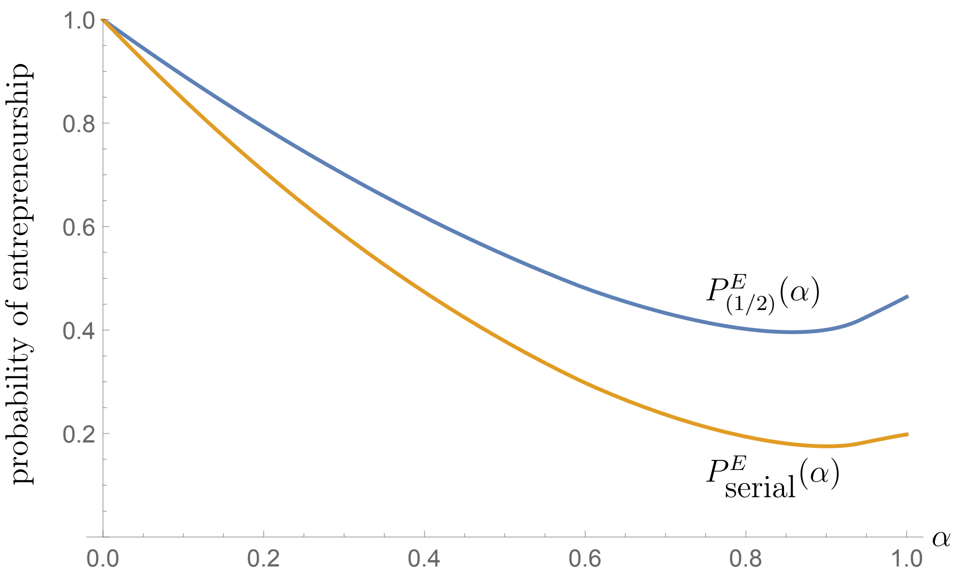


Fig. 5: Serial and Time Average Probabilities of Entrepreneurship as a function of α. ($\beta = 0.9$, $\lambda = 1.5$, $p = 0.45$, $h_A = 0.9$, $l_A = 0.1$, $h_B = 0.4$, $l_B = 0.6$)

6 Additional Implications

6.1 Wages of Past Workers and Past Entrepreneurs

As already discussed in the literature review, our model generates novel predictions with respect to the wage of former workers relative to the wage of *former* entrepreneurs who *change* occupation. As we established in section 5, as α changes, the task allocations of workers and of entrepreneurs change in opposite directions. As α increases, workers are more likely to be allocated to task $\tau = B$ while entrepreneurs are more likely to choose task $\tau = A$. In the limit case of $\alpha = 1$ all workers are allocated to $\tau = B$ and a positive mass of entrepreneurs (the learning entrepreneurs) chooses instead task A. It follows, therefore, that for α sufficiently large the period 2 wage of a former entrepreneur is greater than the period-2 wage of a former worker.

On the other hand, when $K^A(\alpha) \geq k^A(1)$ (i.e., the task allocation within firms is efficient), workers learn more than entrepreneurs in period 1. The next lemma shows that this condition is equivalent to α being small enough.

Lemma 3. *For $\alpha \leq 1 - 2(1 + \lambda^2)(1 - \beta)$, workers are more likely than entrepreneurs to work on task A in period 1.*

It follows that, when $\alpha \leq 1 - 2(1 + \lambda^2)(1 - \beta)$, the period-2 wage of former workers who receive a wage offer is larger than that of former entrepreneurs.

Of course, the average wage of former workers also depends on the payoff of former workers who did not receive an outside offer. However, the above lemma shows that if β is large (i.e. degree of contract incompleteness is low) even a small degree of labor market frictions can induce an efficient task allocation within firms. In this case, there exist values of α such that workers are more likely than entrepreneurs to work on task A, and at the same time the fraction of period-1 workers who do not receive a wage offer is low. For those values of α, on average, former entrepreneurs receive *lower* wages compared to former workers of equivalent characteristics.

There are unfortunately few empirical analysis relative to the compensations of former entrepreneurs who change occupation. Nevertheless, our results are consistent with the existing empirical evidence. Hamilton (2000) shows that US entrepreneurs who leave entrepreneurship and re-enter the labor market after some years earn higher wages than comparable workers: the median entrepreneur returning to paid employment after 10 years as an entrepreneur earns a wage that is 15% higher than a comparable worker who never left employment.[13] Our model suggests an opposite result for high labor market friction economies (the wage of former entrepreneurs is lower than the wage of workers who have never left employment) which is consistent with the finding in Baptista, Lima, and Preto (2012) for Portugal.[14]

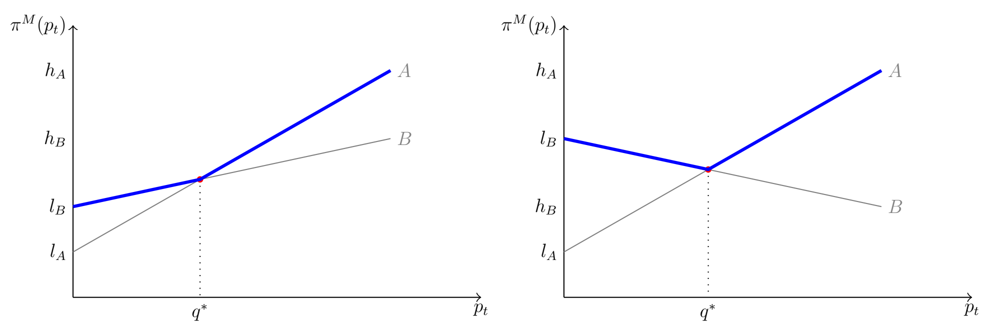
[13] See Table 6 and the discussion on pages 625-626 of Hamilton (2000). Hamilton notes that this result is consistent with the findings of Evans and Leighton (1990). See also Daly (2015) for similar results.

[14] Neither Hamilton (2000) nor Baptista, Lima, and Preto (2012) discuss why an agent will leave entrepreneurship.

6.2 The Value of Failures

A failure can be beneficial to an agent if it allows a better allocation of talent in the next period. As we will show shortly, failures have this property only if the agent has worked on the advanced task *and if* talent is horizontal.

Figure 6 illustrates how the maximum probability of success $\pi^M(p_t)$ varies as a function of the belief that the agent is a high type.[15] As is apparent, when talent is vertical, the success probability is monotonically increasing, but if instead talent is horizontal, the success probability is non monotonic. That is, being a l type for sure is better than being uncertain about whether the agent is h or l type (but worse than being certain that the agent is a h type).



(a) Vertical case: $h_B > l_B$ (b) Horizontal case: $h_B < l_B$

Fig. 6: Maximum probability of success as a function of belief p_t.

Remember from Section 4 that when talent is vertical, failures reduce the probability of being a h type (more so when the failure is at task A) since h types are more likely to succeed than l types at any task. Hence, when talent is vertical failures are always *bad news* because they decrease the probability of success in period 2 relative to the initial probability of success, that is:

$$\pi^M(p_2(\tau_1, 0)) < \pi^M(p_1) \text{ for all } \tau_1 \in \{A, B\}.$$

[15] This probability is obtained by allocating an agent to the task with the highest probability of success, see Equation 4 for the formal definition.

In the horizontal talent case, instead, failures at task A increase the probability that the agent is a low type. By Assumption 2, such failures are *good news* because they lead to an increase of the future probability of success (relative to no history). Instead, failures at task B increase the probability that the agent is of type h, and may be good or bad news depending on the prior belief p_1: if p_1 is sufficiently close to q^* failures at task B are also good news; if instead p_1 is sufficiently low (for example, p_1 such that $\pi^M(p_2(B,0)) < q$), then failures at task B are bad news. The following Lemma formalizes these observations.

Lemma 4. *(i) In the vertical-talent case failures are always bad news, that is,* $\pi^M(p_2(\tau_1,0)) < \pi^M(p_1)$ *for all* $\tau_1 \in \{A,B\}$.

(ii) In the horizontal-talent case, failures at task A *are always good news, that is,* $\pi^M(p_2(A,0)) > \pi^M(p_1)$. *There is a threshold* q_B *such that failures at task* B *are bad news for* $p_1 < q_B$ *and good news for* $p_1 > q_B$.

The vertical view of talent implies that failures should reduce the probability of a future success. Instead, when talent is horizontal, failures can be "good news" depending on the task allocation. In this case, if labor market frictions are low (i.e., high α) and the majority of entrepreneurs are learning entrepreneurs (i.e., λ low), entrepreneurs will choose $\tau_1 = A$ and a failure at this task leads to an increase in the future probability of success. This motivates the following proposition that relates the degree of labor market friction to the value of failures.

Proposition 3. *For a serial entrepreneur, the probability of succeeding as an entrepreneur in period 2 is increasing in* α. *Furthermore*

(i) If talent is vertical, failures are always "bad news". That is, the probability of succeeding in period 2 as an entrepreneur following an entrepreneurial failure in period 1 is below the initial probability of success $\sigma_1(B)$ *for all* α.

(ii) If talent is horizontal, there exist parameter values such that failures are good news for α *sufficiently high, and bad news for* α *sufficiently low.*

With respect to the existing evidence, in the US entrepreneurial failures seem to lead to entrepreneurial success. For example, Gompers, Kovner, Lerner, and Scharfstein (2010) show that entrepreneurs who previously failed are marginally more likely to succeed than first time entrepreneurs. Again the evidence available for Europe tells a very different story. Using German data, Gottschalk, Greene, Höwer, and Müller (2014) show that entrepreneurs who have previously failed are subsequently more likely to fail than first time entrepreneurs. Our model explains these different values of failure if talent is *horizontal*: different agents have an absolute advantage at different tasks. Instead, when talent is *vertical* (that is, the same agent has an absolute advantage at all tasks) failures are always bad news, independently of the level of labor market frictions, a finding which seems counterfactual.

6.3 Age profile of entrepreneurs

At $\alpha = 1$, there are no necessity entrepreneurs. Furthermore, both old and young agents become opportunity entrepreneurs whenever $k_t > K_t$, which implies that there is the same number of old and young opportunity entrepreneurs. Learning entrepreneurs, however, exist only in period 1. By continuity, therefore, for α sufficiently large young agents are more likely than old agents to become entrepreneurs.

For lower values of α, however, other effects come into play. For example, young agents anticipate that, if they become entrepreneurs, they may not be able to find a job in the future. This concern is absent for old agents, which implies that there are more old opportunity entrepreneurs than young opportunity entrepreneurs. It is therefore possible that, for some intermediate α, old people are more likely to be entrepreneurs than young people. Simulations show that this is indeed a possibility.

We are not aware of any evidence linking the effect of age on the probability of becoming an entrepreneur with the degree of labor market friction. A recent paper (Azoulay, Jones, Kim, and Miranda, forthcoming) shows that old entrepreneurs are more likely *to succeed* than young entrepreneurs. This is consistent with the model, because experience generates learning (independently from an agent occupation or task allocation), which can then be used in the choice of task allocation.

6.4 Output

In period 1 a fraction $1-\alpha$ of the population will not receive a wage offer and is forced into entrepreneurship, while a fraction α of the population chooses entrepreneurship or wage work depending on the two period output generated by these two options. Hence, the two-period total expected output in the economy is

$$(1-\alpha)\cdot E[W^E(k_1,\alpha)] + \alpha\cdot E[\max\left\{W^E(k_1,\alpha), W^F(K_1,\alpha)\right\}].$$

Therefore, for a fixed $W^F(k_1,\alpha)$, total expected output increases with α both because fewer agents become necessity entrepreneurs, and because $E[W^E(k_1,\alpha)]$ increases with α. At the same time, $W^F(k_1,\alpha)$ is decreasing with α, because as α approaches 1 firms are unable to implement the two-period output maximizing task allocation. It is theoretically possible that total output is decreasing over some range of α.[16] However, our numerical simulations suggest that output is an increasing function of α for most values of β, λ, p, h_A, l_A, h_B and l_B.

The model helps clarify how a specific realization of the aggregate shock K_1 affects the incentive of firms to learn, the number and motives of entrepreneurs, and total output. A key observation is that the value of working for a firm $W^F(K_1,\alpha)$ is discontinuous at $K_1 = K^A(\alpha)$ when α is large. Therefore, a small decrease in K_1 from above $K^A(\alpha)$ to below $K^A(\alpha)$ will cause a reallocation of workers from task B (the inefficient task allocation) to task A (the efficient task allocation), leading to the following corollaries:

[16] For example, if β is large, a small amount of labor market frictions is sufficient to induce the efficient task allocation within firms. In this case, for α close to 1 the task allocation within firms is efficient while for $\alpha = 1$ it is not, and therefore output increases in α for α close to 1.

- Period-1 output decreases by more than the change in K_1. The reason is the change in period-1 allocation from $\tau_1 = B$ to $\tau_1 = A$, that is from the task with the highest probability of success in period 1 to the task with the lowest probability of success in period 1.
- The number of period-1 entrepreneurs decreases, because the learning motive for entrepreneurship disappears.
- Period-2 output generated within firms increases because period-1 workers are now allocated to the learning-maximizing task allocation.
- Total two-period expected output also increases. There are two causes for this increase. The drop in K_1 from above $K^A(\alpha)$ to below $K^A(\alpha)$ generates an upward jump in $W^F(K_1, \alpha)$, that is, in the sum of the two-period outputs produced within firms. At the same time, more agents in period 1 will choose to work for a firm rather than becoming an entrepreneur.

Therefore, although K_1 and k_1 are independent from K_2 and k_2, the aggregate shock realized in period 1 has long term implications for future output because it determines firms' incentives to learn.

Instead, for α low $W^F(K_1, \alpha)$ is continuous and the task allocation implemented within firms maximizes two-period output. Here, total two-period output is monotonic in K_1.

7 Conclusion

Ceteris-paribus, the intensity of labor-market frictions determines the proportion of different types of entrepreneurs in the economy, the relative wages of former entrepreneurs and former workers, and the probability of becoming an entrepreneur. By focusing on labor market frictions, our model provides a set of results that are consistent with evidence both for the US and for the EU, which are examples of low and high labor market frictions.

In order to focus on the learning motive for entrepreneurship, we have ignored other important determinants of entrepreneurial activity, such as financial constraints, skill acquisition, learning by doing, or differential ability of agents to become entrepreneurs.

In our model, when entrepreneurs face financial constraints, the effect of labor market frictions on entrepreneurial activity will be stronger. Indeed, if the labor market is frictionless, firms' competition insures that workers are able to appropriate the full benefit of learning. Hence firms adopt a less informative task allocation independently of the importance of financial constraints. However, when there are labor-market frictions, financial constraints limit the exit of workers into entrepreneurship and therefore increase the ability of firms to appropriate the benefit of learning.[17] Hence, labor-market frictions and financial constraints are complementary since they increase the likelihood that learning will occur within firms.

There is an element of learning by doing in our model because agents acquire information about their comparative advantage, are better able to match their talent to a task, and therefore increase their productivity over time. We do not however allow agents to increase their productivity on a given task by simply working on that task, that is, there is no task-specific human capital (see Gibbons and Waldman, 1999 and Gibbons and Waldman, 2004). Our results stand as long as this increase in productivity is small compared to the benefit of learning one's comparative advantage.

We have assumed that the production process involves only one task. By contrast, Lazear (2004) assumes that workers work at a single task while entrepreneurs work at multiple tasks and he shows, both theoretically and empirically, that people with a more balanced skill set enter entrepreneurship. Åstebro, Chen, and Thompson (2011), building on Lazear (2004), propose a model in which agents choose between self-employment (in which case they work on multiple tasks) and wage work (in which case they are allocate to a specific task). Exogenous frictions prevent both the efficient assignment of agents to firms, and also the efficient assignment of workers to tasks. These

[17] On the role of financial constraints, see Hellmann (2007), who shows that cash constraints shape the way ideas are financed, within or outside the firm, and Terviö (2009), who argues that, absent long-term contracts, financial constrains may prevent optimal talent discovery in firms.

frictions are the reason why some agents may become self employed. Both in Lazear (2004) and Åstebro et al. (2011) agents' productivity at different tasks are perfectly known, and hence there is no learning. This implies that, for example, these models do not make predictions with respect to the wage of former entrepreneurs. It would be interesting to add uncertainty about talent to Lazear's framework, and study if and how learning determines agents' occupational choices. This extension is left for future work.

Finally, one may be tempted to interpret the case of high labor market frictions as illustrative of developing countries, and there is indeed ample evidence that many people living in developing countries are "reluctant" entrepreneurs (Banerjee and Duflo, 2011). However, we refrain from this temptation. We use the model to explore the effect of labor market frictions keeping everything else constant. This may be a reasonable way to proceed when comparing countries (such as the US and European countries) that have different levels of labor market frictions but are otherwise similar in their contracting abilities, the development of their financial markets, and their level of human capital. But this is hardly the case for developing countries. These other dimensions are not part of our model but are likely to affect the type, frequency and market rewards of entrepreneurial ventures in developing countries.

A Mathematical Appendix

Proof of Proposition 1

Necessary condition for informativeness. Independently of the task assignment in the first period, Bayesian updating implies that

$$\mathbb{E}_{s_1 \in \{0,1\}} \pi(\tau_1, p_2(\tau_1, s_1)) p_2(\tau_1, s_1) = p_1. \tag{8}$$

Because of Assumption 2, there is a realization of s_1 such that the posterior $p_2(\tau_1, s_1)$ is inferior to q^*, leading to task B being adopted in period 2. Since the expected probability of success $\pi^M(p_t)$ is linear when $p \leq q^*$, a necessary condition for A to be more informative than B is that $\max_{s_1} p_2(A, s_1) > q^*$.

Because in both the vertical and horizontal cases $\frac{h_A}{l_A} > \frac{1-h_A}{1-l_A}$, the maximum posterior following task A is achieved following a success. More informativeness of A therefore requires that $p_2(A,1) > q^*$, that is

$$p_1 > q_A \equiv \left(1 + \frac{h_A}{l_A}\frac{h_A - h_B}{l_B - l_A}\right)^{-1} \tag{9}$$

Sufficient condition for (weak) informativeness. Since the maximum probability of success is a convex function of the posterior, whenever the distribution of posteriors following $\tau_1 = A$ is a mean preserving spread of the distribution of the distribution following $\tau_1 = B$, we will have $\sigma_2(A) \geq \sigma_2(B)$. Using our previous remark that $\max_{s_1} p_2(A, s_1) = p_2(A, 1)$, the distribution of posteriors following A is a mean-preserving spread of the distribution following B whenever:

$$p_2(A,0) < \min_{s_1} p_2(B, s_1) < p_1 < \max_{s_1} p_2(B, s_1) < p_2(A,1). \tag{MPS}$$

Under the above condition, $\sigma_2(A) = \sigma_2(B)$ if and only if $p_1 \leq q_A$, that is if and only if no matter the task allocation and the realization of success and failure in period 1 the agent is always allocated to task B in period 2. Hence, (MPS) and $p_1 > q_A$ are sufficient for $\sigma_2(A) > \sigma_2(B)$.

When talent is vertical, $h_A > h_B > l_B > l_A$, and the posteriors are ordered as

$$p_2(A,0) < p_2(B,0) < p_1 < p_2(B,1) < p_2(A,1).$$

and (MPS) is automatically satisfied.

When talent is horizontal, $l_B > h_B$ implies that

$$p_2(B,1) < p_1 < p_2(B,0) \text{ and } p_2(A,0) < p_1 < p_2(A,1),$$

but not necessarily (MPS). The distribution of posteriors following A is a mean preserving spread of the distribution of posterior following B whenever $p_2(A,1) > p_2(B,0)$ and $p_2(A,0) < p_2(B,1)$. Simple algebra shows that these conditions are equivalent to $h_A - l_A > l_B h_A - l_A h_B > l_B - h_B$, which is therefore sufficient for $\sigma_1(A) < \sigma_1(B)$ but $\sigma_2(A) > \sigma_2(B)$ in the horizontal case.

Generalization of Proposition 1

Proposition 1 only provides sufficient conditions for $\sigma_1(A) < \sigma_1(B)$ but $\sigma_2(A) > \sigma_2(B)$ in the horizontal case. Here we instead provide *necessary* and sufficient conditions for $\sigma_1(A) < \sigma_1(B)$ but $\sigma_2(A) > \sigma_2(B)$ in the horizontal case.

Proposition 4. *Under assumption 2, in the horizontal talent case there is a conflict between today's probability of success and tomorrow's if and only if* $q_A < p_1$ *and one of the following conditions hold:*

- $\frac{l_B}{h_B} < \frac{1-l_A}{1-h_A}$ *and* $\frac{l_A}{h_A} < \frac{1-l_B}{1-h_B}$,
- $\frac{l_B}{h_B} > \frac{1-l_A}{1-h_A}$, $\frac{l_A}{h_A} < \frac{1-l_B}{1-h_B}$, $1 < h_A + h_B$, *and* $1 < l_A + l_B$,
- $\frac{l_B}{h_B} > \frac{1-l_A}{1-h_A}$, $\frac{l_A}{h_A} < \frac{1-l_B}{1-h_B}$, *and* $l_A + l_B < h_A + h_B < 1$,
- $\frac{l_B}{h_B} > \frac{1-l_A}{1-h_A}$, $\frac{l_A}{h_A} < \frac{1-l_B}{1-h_B}$, $h_A + h_B < l_A + l_B < 1$, *and* $p_1 < q^{ooo}$.
- $\frac{l_B}{h_B} < \frac{1-l_A}{1-h_A}$, $\frac{l_A}{h_A} > \frac{1-l_B}{1-h_B}$, $1 < l_A + l_B < h_A + h_B$ *and* $p_1 > q^{ooo}$,

where

$$q^{ooo} \equiv \left(1 + \frac{h_A - h_B}{l_B - l_A}\frac{1-(h_A+h_B)}{1-(l_A+l_B)}\right)^{-1}.$$

Proof. We already argued in the body of the text that

$$p_1 > q_A \equiv \left(1 + \frac{h_A}{l_A}\frac{h_A - h_B}{l_B - l_A}\right)^{-1}, \tag{10}$$

is a necessary condition for $\sigma_2(A) > \sigma_2(B)$. Note that this condition is consistent with $p_1 < p^\star$ because $h_A > l_A$ and therefore $q_A < q^*$.

Using the expression for the posterior probability $p_2(\tau_1, s_1)$, we have that whenever

$$\frac{l_B}{h_B} < \frac{1-l_A}{1-h_A}, \tag{11}$$

then $p_2(A,0) < p_2(B,1) < p_1$ in the horizontal talent case, and $p_2(A,0) < p_2(B,0) < p_1$ in the vertical talent case. Whenever

$$\frac{l_A}{h_A} < \frac{1-l_B}{1-h_B}, \tag{12}$$

then $p_1 < p_2(B,0) < p_2(A,1)$ in the horizontal talent case, and $p_1 < p_2(B,1) < p_2(A,1)$ in the vertical talent case. Hence, whenever (11) and (12) hold the distribution of posteriors if $\tau_1 = A$ is a mean-preserving spread of the distribution of posteriors if $\tau_1 = B$, and we are in the case considered in the body of the text. Conditions (11) and (12) always hold when talent is vertical (i.e., $l_B \geq h_B$), but may not hold when talent is horizontal. For the horizontal talent case, therefore, we need to consider few additional cases.

Horizontal talent, both (11) and (12) are violated. In this case $p_2(B,1) < p_2(A,0) < p_1 < p_2(A,1) < p_2(B,0)$. The distribution of posteriors if $\tau_1 = B$ is a mean-preserving spread of the distribution of posteriors if $\tau_1 = A$, and $\tau_1 = A$ generates *less* learning and a *lower* probability of success in period 2 than $\tau_1 = B$.

Horizontal talent, (12) holds but (11) is violated. In this case $p_2(B,1) < p_2(A,0) < p_1 < p_2(B,0) < p_2(A,1)$. Hence, if $p_2(B,0) < q^*$, task B is not informative, because both in case of success and failures the period-2 task allocation will again be B. Hence, condition (10) is sufficient for learning to be beneficial. Simple algebra shows that $p_2(B,0) < q^*$ whenever

$$p_1 < q^{oo} \equiv \left(1 + \frac{1-h_B}{1-l_B}\frac{h_A - h_B}{l_B - l_A}\right)^{-1}.$$

Note that, by 12, $q_A < q^{oo} < q^*$. Hence, $\tau_1 = A$ generates more learning and a higher probability of success in period 2 if $q_A < p_1 < q^{oo}$.

For $q^{oo} < p_1 < q^*$, $p_2(B,0) > q^*$. That is, following a failure at task B the agent is allocated to task A in period 2. It follows that

$$\sigma_2(A) = p_1 h_A^2 + (1-p_1) l_A^2 + p_1(1-h_A)h_B + (1-p_1)(1-l_A)l_B \text{ if } p_1 > q^{oo}$$
$$\sigma_2(B) = p_1 h_B^2 + (1-p_1) l_B^2 + p_1(1-h_B)h_A + (1-p_1)(1-l_B)l_A \text{ if } p_1 > q^{oo}$$

and therefore:

$$\sigma_2(A)-\sigma_2(B) = (1-p_1)(l_B-l_A)(1-(l_B+l_A))-p_1(h_A-h_B)(1-(h_A+h_B)) \text{ if } p_1 > q^{oo}. \tag{13}$$

There are few subcases to consider:

- Whenever $h_A + h_B > 1$ and $l_B + l_A < 1$, then 13 is always positive. However, this case is incompatible with (11) being violated.
- Whenever $h_A+h_B < 1$ and $l_B+l_A > 1$, (13) is always negative. However, $h_A + h_B < 1$ and $l_B + l_A > 1$ is incompatible with (12).
- Whenever $h_A + h_B < 1$ and $l_B + l_A < 1$, then (13) is positive whenever

  $$p_1 < q^{ooo} \equiv \left(1 + \frac{h_A - h_B}{l_B - l_A}\frac{1-(h_A+h_B)}{1-(l_A+l_B)}\right)^{-1},$$

  In this case condition (12) imply $\frac{1-(h_A+h_B)}{1-(l_A+l_B)} < \frac{1-h_B}{1-l_B}$, so that $q^{ooo} > q^{oo}$. Furthermore, $q^{ooo} < q^*$ if and only if $l_A + l_B > h_A + h_B$. Hence, when (12) holds, (11) is violated, $h_A+h_B < l_B+l_A < 1$, we have that $\sigma_2(A) > \sigma_2(B)$ if and only if $q_A < p_1 < q^{ooo}$. When (12) holds, (11) is violated, $l_B+l_A < h_A+h_B < 1$, we have that $\sigma_2(A) > \sigma_2(B)$ if and only if $q_A < p_1$.
- Whenever $h_A + h_B > 1$ and $l_B + l_A > 1$, (13) is positive whenever

  $$p_1 > q^{ooo} \equiv \left(1 + \frac{h_A - h_B}{l_B - l_A}\frac{1-(h_A+h_B)}{1-(l_A+l_B)}\right)^{-1},$$

  In this case condition (12) imply $\frac{1-(h_A+h_B)}{1-(l_A+l_B)} > \frac{1-h_B}{1-l_B}$, so that $q^{ooo} < q^{oo}$. Hence, when (12) holds, (11) is violated, $l_B + l_A > 1$ and $h_A + h_B > 1$, we have that $\sigma_2(A) > \sigma_2(B)$ if and only if $p_1 > q_A$.

Horizontal talent, (12) **is violated but** (11) **holds.** In this case $p_2(A,0) < p_2(B,1) < p_1 < p_2(A,1) < p_2(B,0)$. Hence, if $p_2(A,1) > q^*$, then also $p_2(B,0) > q^*$. For any $p_1 > q$, the difference between $\sigma_2(A)$ and $\sigma_2(B)$ is again given by (13). Going through the same subcases, we get

- Whenever $h_A + h_B > 1$ and $l_B + l_A < 1$, then 13 is always positive. However, this case is incompatible with (12) being violated.

- Whenever $h_A + h_B < 1$ and $l_B + l_A > 1$, (13) is always negative. However, $h_A + h_B < 1$ and $l_B + l_A > 1$ is incompatible with (11).

- Whenever $h_A + h_B < 1$ and $l_B + l_A < 1$, then (13) is positive whenever

$$p_1 < q^{ooo} \equiv \left(1 + \frac{h_A - h_B}{l_B - l_A} \frac{1 - (h_A + h_B)}{1 - (l_A + l_B)}\right)^{-1},$$

  In this case, the fact that (12) is violated imply $q^{ooo} < q_A$. Hence this condition never leads to $\sigma_2(A) > \sigma_2(B)$.

- Whenever $h_A + h_B > 1$ and $l_B + l_A > 1$, (13) is positive whenever

$$p_1 > q^{ooo} \equiv \left(1 + \frac{h_A - h_B}{l_B - l_A} \frac{1 - (h_A + h_B)}{1 - (l_A + l_B)}\right)^{-1},$$

  In this case, the fact that (12) is violated imply $q^{ooo} > q_A$. Note also that $q^{ooo} < q^*$ if and only if $l_A + l_B < h_A + h_B$. Hence, when (11) holds, (12) is violated, $1 < l_A + l_B < h_A + h_B > 1$ we have that $\sigma_2(A) > \sigma_2(B)$ if and only if $p_1 > q^{ooo}$.

□

Omitted calculations relative to Section 5

For the reader's convenience, we report here all the calculations relative to Section 5:

$$\mathbb{E}[k_2] = \int_0^2 \left[\int_0^{\lambda K_2} k_2 \frac{dk_2}{\lambda K_2} \right] \frac{dK_2}{2}$$
$$= \int_0^2 \frac{\lambda K_2}{2} \frac{dK_2}{2}$$
$$= \frac{\lambda}{2}$$

$$\begin{aligned}
\mathbb{E}[\max\{K_2 - k_2, 0\}] &= \int_0^2 \left[\int_0^{K_2} (K_2 - k_2) \frac{dk_2}{\lambda K_2} \right] \frac{dK_2}{2} \\
&= \int_0^2 \left(K_2^2 - \frac{K_2^2}{2} \right) \frac{1}{\lambda K_2} \frac{dK_2}{2} \\
&= \int_0^2 \left(\frac{K_2}{2\lambda} \right) dK_2 = \frac{1}{2\lambda}.
\end{aligned}$$

$$\begin{aligned}
\mathbb{E}[\max\{k, K\}] &= \int_0^2 \left[\int_0^K K f(k|K) dk + \int_K^{\lambda K} k f(k|K) dk \right] \frac{dK}{2} \\
&= \int_0^2 \left[\int_0^K \frac{1}{\lambda} dk + \int_K^{\lambda K} k \frac{1}{\lambda K} dk \right] \frac{dK}{2} \\
&= \int_0^2 \left[\frac{K}{\lambda} + \frac{(\lambda K)^2 - K^2}{2\lambda K} \right] \frac{dK}{2} \\
&= \int_0^2 \left[\frac{K}{\lambda} + \frac{K(\lambda^2 - 1)}{2\lambda} \right] \frac{dK}{2} \\
&= \frac{1}{\lambda} + \frac{\lambda^2 - 1}{2\lambda} = \frac{1}{2} \left(\lambda + \frac{1}{\lambda} \right).
\end{aligned}$$

Proof of Lemma 2

Because $W^F(K_1, \alpha)$ is discontinuous at $K_1 = K^A(\alpha)$ whenever $K^A(\alpha) < k^A(1)$, by definition $k^E(K_1, \alpha)$ is also discontinuous at $K_1 = K^A(\alpha) < k^A(1)$. Note also that for $K_1 \leq K^A(\alpha) \leq k^A(1)$ the task allocation within firm is efficient, while for $K_1 \in (K^A(\alpha), k^A(1))$ it is not. It follows that, whenever

$K^A(\alpha) < k^A(1)$ we have

$$W^F(K^A(\alpha), \alpha) > \lim_{K_1 \to K^A(\alpha)^+} W^F(K_1, \alpha),$$

and therefore

$$k^E(K^A(\alpha), \alpha) > \lim_{K_1 \to K^A(\alpha)^+} k^E(K_1, \alpha)$$

At every point at which $k^E(K_1, \alpha)$ is differentiable with respect to K_1, by the implicit function theorem

$$\frac{\partial k^E(K_1, \alpha)}{\partial K_1} = \begin{cases} 1 & \text{if } (K_1 - K^A(\alpha))(k^E(K_1, \alpha) - k^A(\alpha)) \geq 0 \\ \frac{\sigma_1(A)}{\sigma_1(B)} & \text{if } K_1 - K^A(\alpha) < 0 \text{ \& } k^E(K_1, \alpha) - k^A(\alpha) > 0 \\ \frac{\sigma_1(B)}{\sigma_1(A)} & \text{if } K_1 - K^A(\alpha) > 0 \text{ \& } k^E(K_1, \alpha) - k^A(\alpha) < 0. \end{cases}$$

Similarly, at every point at which $k^E(K_1, \alpha)$ is differentiable with respect to α, by the implicit function theorem

$$\frac{\partial k^E(K_1, \alpha)}{\partial \alpha} = -\frac{1}{2\lambda} \begin{cases} \frac{\sigma_2(A)}{\sigma_1(A)} & \text{if } k^E(K_1, \alpha) \leq k^A(\alpha) \\ \frac{\sigma_2(B)}{\sigma_1(B)} & \text{otherwise.} \end{cases}$$

We can therefore write

$$k^E(K_1, \alpha) = \begin{cases} Z(K_1, \alpha) & \text{if } K_1 \leq K^A(\alpha) \\ Y(K_1, \alpha) & \text{otherwise,} \end{cases}$$

where $Z(K_1, \alpha)$ and $Y(K_1, \alpha)$ are two continuous functions, increasing in K_1 and decreasing in α, with $Z(K_1, \alpha) = Y(K_1, \alpha)$ for $K_1 \geq k^A(1)$ and $Z(K_1, \alpha) > Y(K_1, \alpha)$ for $K_1 < k^A(1)$.

We can now compute[18]

$$\text{pr}\{k_1 > k^E(K_1,\alpha)\} = \int_0^2 \frac{1}{2}\min\left\{\max\left\{1-\frac{k^E(K_1,\alpha)}{\lambda K_1},0\right\},1\right\} dK_1$$
$$= \frac{1}{2}\left(\int_0^{K^A(\alpha)} \min\left\{\max\left\{1-\frac{Z(K_1,\alpha)}{\lambda K_1},0\right\},1\right\} dK_1 + \int_{K^A(\alpha)}^2 \min\left\{\max\left\{1-\frac{Y(K_1,\alpha)}{\lambda K_1},0\right\},1\right\} dK_1\right)$$

which is continuous because the integrand has only finitely many discontinuities.

It follows that

$$\frac{\partial \text{pr}\{k_1 > k^E(K_1,\alpha)\}}{\partial\alpha} = \frac{1}{2}\int_0^2 \mathbb{1}\{0 \le k^E(K_1,\alpha) \le \lambda K_1\}\left(1-\frac{1}{\lambda K_1}\frac{\partial k^E(K_1,\alpha)}{\partial\alpha}\right) dK_1$$
$$+\frac{\partial K^A(\alpha)}{\partial\alpha}\left(\min\left\{\max\left\{1-\frac{Z(K^A(\alpha),\alpha)}{\lambda K^A(\alpha)},0\right\},1\right\} - \min\left\{\max\left\{1-\frac{Y(K^A(\alpha),\alpha)}{\lambda K^A(\alpha)},0\right\},1\right\}\right)$$

is positive because $\frac{\partial k^E(K_1,\alpha)}{\partial\alpha} < 0$, $\frac{\partial K^A(\alpha)}{\partial\alpha} < 0$, and $Y(K^A(\alpha),\alpha) < Z(K^A(\alpha),\alpha)$ (so that the last terms in brackets is negative), and continuous because, again, $\frac{\partial k^E(K_1,\alpha)}{\partial\alpha}$ has only finitely many discontinuities.

Therefore

$$\frac{\partial P_1^E(\alpha)}{\partial\alpha} = \alpha\frac{\partial \text{pr}\{k_1 > k^E(K_1,\alpha)\}}{\partial\alpha} - (1-\text{pr}\{k_1 > k^E(K_1,\alpha)\})$$

is negative at $\alpha = 0$ because

$$\frac{\partial \text{pr}\{k_1 > k^E(K_1,\alpha)\}}{\partial\alpha}|_{\alpha=0} = \frac{1}{2}\int_0^2 \mathbb{1}\{0 \le k^E(K_1,\alpha=0) \le \lambda K_1\}\left(1-\frac{1}{\lambda K_1}\frac{\partial k^E(K_1,\alpha=0)}{\partial\alpha}\right) dK_1$$

is finite.

At $\alpha = 1$ instead we have

$$\frac{\partial P_1^E(\alpha)}{\partial\alpha}|_{\alpha=1} = \frac{1}{2}\int_0^2 \mathbb{1}\{k^E(K_1,\alpha=1) > 0\}\left(1-\frac{1}{\lambda K_1}\frac{\partial k^E(K_1,\alpha=1)}{\partial\alpha}|_{\alpha=1}\right) dK_1$$
$$-\frac{\partial K^A(\alpha)}{\partial\alpha}|_{\alpha=1}\frac{1}{\lambda} - \left(1-\text{pr}\{k_1 > k^E(K_1,\alpha=1)\}\right)$$
$$= \text{pr}\{k_1 > k^E(K_1,\alpha=1)\} + \text{pr}\{k^E(K_1,\alpha=1) > 0\} - 1$$
$$-\frac{1}{2}\int_0^2 \mathbb{1}\{k^E(K_1,\alpha) > 0\}\frac{1}{\lambda K_1}\frac{\partial k^E(K_1,\alpha=1)}{\partial\alpha}|_{\alpha=1} dK_1 - \frac{\partial K^A(\alpha)}{\partial\alpha}|_{\alpha=1}\frac{1}{\lambda}$$

[18] Remember that, by definition, $k^E(K_1,\alpha)$ can be greater that λK_1 or smaller that zero.

where we used the fact that at $\alpha = 1$, $Z(K_1, \alpha = 1) = K_1$, that is, assuming that the task allocation is efficient and that there are no labor market frictions, agents become entrepreneurs only if they have a project that is more valuable than that of firms. Furthermore $K^A(\alpha = 1) = 0$, and hence $k^E(K_1, \alpha = 1) \leq K_1$, and $Y(K^A(\alpha = 1), \alpha = 1) < 0$.

Define $\tilde{K} \equiv K_1 : k^E(K_1, \alpha = 1) = 0$. We can write

$$\begin{aligned}\text{pr}\{k_1 > k^E(K_1, \alpha = 1)\} =& \text{pr}\{K_1 < \tilde{K}_1\} \\ &+ (1 - \text{pr}\{K_1 < \tilde{K}_1\}) \cdot \text{pr}\{k_1 > k^E(K_1, \alpha = 1) | k^E(K_1, \alpha = 1) > 0\}\end{aligned}$$

and

$$\text{pr}\{k^E(K_1, \alpha = 1) > 0\} = 1 - \text{pr}\{K_1 < \tilde{K}_1\}$$

Using this, we can rewrite

$$\begin{aligned}\frac{\partial P_1^E(\alpha)}{\partial \alpha}|_{\alpha=1} = -\frac{1}{2}\int_0^2 \mathbb{1}\{k^E(K_1, \alpha) > 0\} \frac{1}{\lambda K_1} \frac{\partial k^E(K_1, \alpha = 1)}{\partial \alpha}|_{\alpha=1} dK_1 - \frac{\partial K^A(\alpha)}{\partial \alpha}|_{\alpha=1} \frac{1}{\lambda} \\ + (1 - \text{pr}\{K_1 < \tilde{K}_1\}) \cdot \text{pr}\{k_1 > k^E(K_1, \alpha = 1) | k^E(K_1, \alpha = 1) > 0\}\end{aligned}$$

which is positive because, as we already saw, both $\frac{\partial k^E(K_1, \alpha=1)}{\partial \alpha}$ and $\frac{\partial K^A(\alpha)}{\partial \alpha}$ are negative. By continuity, $\frac{\partial P_1^E(\alpha)}{\partial \alpha}$ is decreasing for α sufficiently close to 0, and increasing for α sufficiently close to 1.

Proof of Proposition 2

We can compute

$$\frac{\partial P^E_{\text{serial}}(\alpha)}{\partial \alpha} = \frac{\partial P_1^E(\alpha)}{\partial \alpha}\left(1 - \frac{\alpha}{\lambda}\right) - P_1^E(\alpha)\frac{1}{\lambda},$$

$$\frac{\partial P^E_{1/2}(\alpha)}{\partial \alpha} = \frac{1}{2}\left(\frac{\partial P_1^E(\alpha)}{\partial \alpha}\left(1 + \frac{1-\alpha}{\lambda}\right) - P_1^E(\alpha)\frac{1}{\lambda}\right),$$

which are both negative at $\alpha = 0$ since, by Lemma 2, $P_1^E(\alpha)$ is decreasing at $\alpha = 0$. They are both positive at $\alpha = 1$ if and only if

$$\frac{\partial P_1^E(\alpha = 1)}{\partial \alpha}(\lambda - 1) > P_1^E(\alpha = 1)$$

By the derivations in the proof of Lemma 2, the above expression is satisfied whenever

$$-\frac{\partial K^A(\alpha)}{\partial \alpha}|_{\alpha=1}\frac{1}{\lambda}(\lambda - 1) > 1$$

$$\frac{\lambda - 1}{4\lambda^2(1-\beta)}\frac{\sigma_2(A) - \sigma_2(B)}{\sigma_1(B) - \sigma_1(A)} > 1.$$

Proof of Lemma 3

Assume that α is sufficiently low so that $K^A(\alpha) \geq k^A(1)$. In this case, the task allocation within firms maximizes the two-period output. That is, if an agent works for a firm, he is allocated to task $\tau_1 = A$ if and only if

$$K_1 \leq k^A(1) := \frac{1}{2}\left(\frac{1}{\lambda} + \lambda\right)\left(\frac{\sigma_2(A) - \sigma_2(B)}{\sigma_1(B) - \sigma_1(A)}\right).$$

At the same time, entrepreneurs set $\tau_1 = A$ if and only if

$$k_1 \leq k^A(\alpha) := \frac{\alpha + \lambda^2}{2\lambda}\left(\frac{\sigma_2(A) - \sigma_2(B)}{\sigma_1(B) - \sigma_1(A)}\right) \leq k^A(1).$$

Hence, for any α such that $K^A(\alpha) \geq k^A(1)$, if all agents who receive a wage offer become workers — so that there is no selection into different professions based on k_1 — the probability that a worker is allocated to $\tau = A$ is greater than the probability that an entrepreneur is allocated to $\tau = A$.

To conclude the proof, we need to address the issue of selection into entrepreneurship based on k_1. We use the fact that agents become entrepreneurs if they have a sufficiently valuable project, which makes them less likely to choose the task allocation that maximizes learning. Note that an agent who receives a wage offer chooses to be an entrepreneur rather than working for a firm if and only if

$$\max_{\tau_1 \in \{A,B\}} \left\{ \sigma_1(\tau_1) k_1 + \sigma_2(\tau_1) \frac{\alpha + \lambda^2}{2\lambda} \right\} \geq \max_{\tau_1 \in \{A,B\}} \left\{ \sigma_1(\tau_1) K_1 + \sigma_2(\tau_1) \frac{1}{2} \left(\frac{1}{\lambda} + \lambda \right) \right\}$$

Therefore, for every K_1, there is a threshold $k(K_1) > K_1$ such that for every $k_1 \geq k(K_1)$ the agent becomes an entrepreneur, and for every $k_1 \leq k(K_1)$ the agent becomes a worker. Suppose that $K_1 \leq k^A(1)$, so that all workers are allocated to $\tau = A$. It is easy to see that entrepreneurs are allocated to task $\tau = B$ with positive probability. Suppose instead that $K_1 \geq k^A(1)$, so that workers are allocated to task $\tau = B$. Again, because $k(K_1) > K_1 > k^A(1)$ all agents who become entrepreneurs also set $\tau = B$. It follows that, among agents who receive an offer, the unconditional probability (i.e., for any K_1, k_1) of being allocated to task A is greater for workers than for entrepreneurs.

Proof of Lemma 4

When talent is vertical, we showed in the proof of Proposition 1 that $p_2(A, 0) < p_2(B, 0) < p_1$, which implies that failures always reduce the probability of being a h type (more so when the failure is at task A). Because the function $\pi^M(p_t)$ is monotonically increasing, we have the inequalities $\pi^M(p_2(A, 0)) < \pi^M(p_2(B, 0)) < \pi^M(p_1)$, and hence and failures decrease the probability of success in period 2 relative to the initial probability of success.

Instead, in the horizontal case low types are more likely to succeed at task B than high types and therefore $p_2(A, 0) < p_1 < p_2(B, 0)$. Furthermore, the function $\pi^M(p_2)$ is decreasing for $p_2 < q^*$ and then increasing, implying that $\pi^M(p_2(A, 0)) > \pi^M(p_1)$. Note also that there is a threshold value of p_1 below which $\pi^M(p_2(B, 0)) < \pi^M(p_1)$ (failures at B are bad news) and above which $\pi^M(p_2(B, 0)) > \pi^M(p_1)$ (failures at B are good news). If p_1 is so low that $p_1 < p_2(B, 0) < q^*$, then quite immediately failures are bad news. Whenever instead $p_1 < q^* < p_2(B, 0)$ we have that $\pi^M(p_1)$ is monotonically decreasing in $p_1 < q^*$, but $\pi^M(p_2(B, 0))$ is monotonically increasing in p_1. The statement therefore follows by continuity.

Proof of Proposition 3

For given project value k_1 the probability that an entrepreneur sets $\tau_1 = A$ increases with α. At the same time α determines the set of k_1 that will be pursued by agents who receive a wage offer and become entrepreneurs. For these agents, as α increases, the set of projects that are pursued enlarges: smaller k_1 are pursued by entrepreneurs. These projects are the ones for which the entrepreneurs are more likely to choose $\tau_1 = A$. Overall, the probability of setting $\tau_1 = A$ increases with α, which implies that the probability of succeeding in period 2, also increase with α.

The second part of the Proposition follows by Lemma 4. In the vertical talent case the probability of period-2 success following a failure is always below the initial probability of success $\pi^M(p_1) \equiv \sigma_1(B)$. In the horizontal talent case failures at task A are always good news, while if $p_1 < q_B$ failures at task B are bad news. Hence, if talent is horizontal, $\alpha = 1$ and λ low, for any $p_1 < q_B$ the majority of entrepreneurs are motivated by learning and set $\tau_1 = A$. In this case, failures are good news. As α decreases, the majority of entrepreneurs are opportunity entrepreneurs or necessity entrepreneurs who set $\tau_1 = A$ whenever

$$k_1 \leq k^A(\alpha) := \frac{\alpha + \lambda^2}{2\lambda} \left(\frac{\sigma_2(A) - \sigma_2(B)}{\sigma_1(B) - \sigma_1(A)} \right) \leq k^A(1).$$

and B otherwise. Hence, as α decreases, entrepreneurs are more likely to choose task B. Also, for given α, in the limit case $p_1 \to 0$, we have $\sigma_2(A) \to \sigma_2(B)$ and all entrepreneur choose task B and entrepreneurial failures are bad news. By continuity, there exists a p_1 and $\alpha < 1$ such that entrepreneurial failures are bad news.

B Unobservable Task Allocation

When past task allocation is not observable outside of the firm, at the beginning of period 2 there may be asymmetry of information between firms and any agent who did not work for the same firm previously. We restrict our analysis of this problem to the case $\alpha = 1$. Our goal is to show that the basic finding of the model in the text persists: the learning motive for entrepreneurship emerges when α is high. (It is quite immediate to see that as α decreases the learning motive for entrepreneurship disappears.)

Screening equilibria. Suppose that in period 2, for every observable history, firms offer a contract for every possible type, where a contract has the form $\{b, f, \tau_2\}$ i.e., a bonus, fixed payment, and a task allocation. Clearly, if the agent produced a success in the previous period, a menu of contracts $\{b, f, \tau_2 = A\}$ and $\{b', f', \tau_2 = B\}$ such that $f + qb = f' + qb' = K_2$ is an equilibrium screening menu of contracts, because each firm makes zero profits, agents of different types prefer different contracts (strictly so if $b, b' > 0$), and the firm has no incentive to implement a task allocation that is different from that specified in the contract.[19]

However, in order to use such contracts, it must be the case that conditional on a given outcome s_1, those who worked at different period-1 tasks maximize period-2 probability of success by working at different period-2 tasks. In other words, after observing a failure, screening is possible if those who worked at task $\tau_1 = A$ should work in period 2 on task $\tau_2 = B$, and vice versa. Similarly, after observing a success, screening is possible if those who worked at task $\tau_1 = A$ should work in period 2 again on task $\tau_2 = A$, and the same for those who worked on task $\tau_1 = B$.

This condition is never satisfied when talent is vertical. In this case, successes (whether at task $\tau_1 = A$ or task $\tau_1 = B$) increase the probability that the agent is of type h and that he should be allocated to task $\tau_2 = A$. Similarly failures (whether at task $\tau_1 = A$ or task $\tau_1 = B$) increase the probability that the agent is of type l and that he should be allocated to task B. Hence, in general, screening is not possible when talent is vertical.[20]

[19] Note that this contract amounts to delegating task allocation to the worker. Delegation is possible because, in period 2, workers and firms have aligned preferences regarding task allocation.

[20] It may still, however, be possible to screen conditional on a given period-1 outcome, but not on the other outcome.

Screening is possible whenever talent is horizontal and p_1 is sufficiently close to $p^\star$. In this case, successes at task $\tau_1 = A$ or task $\tau_1 = B$ make it more likely that the agent should work at that task in period 2 as well. Similarly, failures at task $\tau_1 = A$ or task $\tau_1 = B$ makes it more likely that the agent should work at the other task in period 2. If the initial prior is sufficiently uncertain, conditional on the outcome s_1 there is a one-to-one correspondence between τ_1 and τ_2 maximizing period-2 probability of success.

No-screening equilibrium. If workers past task allocation is not observable and screening is not possible, then the contract offered by firms to former workers depends on the market belief over the workers previous task allocation.

It is easy to show, however, that there is no equilibrium in which firms set $\tau_1 = A$ with probability 1. If the market expects $\tau_1 = A$, then the period-1 employer makes zero profits in period 2. Hence, he is better off by maximizing period-1 output and setting $\tau_1 = B$. Of course, it is possible that, in equilibrium firms set $\tau_1 = A$ with positive probability (but less than 1). Still, as in the body of the text, also here some agents may decide to become learning entrepreneurs. The reason is that workers prefer to work on task A (with probability 1) if $K_1 \leq k^A(1)$. Hence, if $k_1 < K_1$ but $K_1 - k_1$ is sufficiently small, some agents will become entrepreneurs despite the fact that their project value is lower of that of firms.

C Long-Term Contracts

In the text we assume that long-term contracts are not available. In this section, we relax this assumption by introducing the possibility that, in period 1, firms and workers can sign a contract specifying a wage for period 2. Again, we limit our attention to the case $\alpha = 1$ (no labor-market frictions) and show that the learning motive for entrepreneurship also emerges with long-term contracts. (As in the previous extension of the model, as α decreases the learning motive for entrepreneurship disappears since firms use the efficient task allocation.)

To start, note that if firms can shutdown at no cost, then there is no equilibrium in which firms set $\tau_1 = A$ with positive probability. As long as workers can freely leave a firm, competition requires that firms' make zero profits in period 2. Hence, a firm period-2 profits are always zero, whether it continues its operation or not. However, if in equilibrium $\tau_1 = A$, a firm is better off by switching to $\tau_1 = B$ and then shutting down the firm (to avoid having to pay the wage corresponding to $\tau_1 = A$ in period 2). Hence, the equilibrium is the same as with short-term contracts.

Suppose instead that firms can commit not to shut down. Long-term contracting does not affect our main qualitative result as long as workers are free to move across firms and occupations. Our argument rests on the fact that a period-1 worker may become an entrepreneur in period 2, which limits the period-2 profits a firm may expect to make from learning its worker's talent in period 1.

If workers are free to leave, any long-term contract signed in period-1 should pay in period 2 at least the period-2 market wage. Therefore, in period 2 a long-term contract pays the worker a wage — contingent on success or failure in period 1 and on period 2 project K_2 — equal to the market value of this worker *if he had been allocated to task* A in period 1.

Assume that such a contract is signed. We argue here that the firm may deviate and set $\tau_1 = B$. For given K_2, this deviation delivers an expected loss in period-2 equal to $K_2(\sigma_2(A) - \sigma_2(B))$, because the employee will have to be paid as if he had worked on task A while instead he worked on task B. However, this loss is realized only if the agent does not become an entrepreneur and continues working for the firm, and hence it is discounted by the probability that $k_2 > K_2$, which is monotonically increasing in λ. At the same time, such deviation increases the probability of success in period 1 and therefore delivers a period-1 gain equal to $(\sigma_1(B) - \sigma_1(A))(K_1 - b)$.

It is easy to see that for λ sufficiently large, the probability that the worker will continue working for the same firm vanishes to zero and the firm will deviate to $\tau_1 = B$. Hence, for λ large, long-term contracts do not always implement the worker-preferred task allocation and therefore the learning motive for entrepreneurship survives.

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