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Abstract

We study the early stages of firm creation under imperfect information. Because startups make error-prone decisions due to rational inattention, the model generates both inefficient entry and labor misallocation. We show that information frictions alter the effects of lump-sum transfers to startups: the total employment gain is amplified due to an unintended increase in inefficient entry, most entrants hire fewer workers, and misallocation goes up. The transfer makes low-size, previously dominated actions profitable, affecting the entire endogenous learning problem and making even productive startups lean toward more conservative hiring. We show that this novel information channel works against well-known mechanisms (for example, financial frictions) and also dampens the effects of alternative policies such as wage subsidies.

Key words: startups, rational inattention, firm subsidy

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1 Introduction

Startups are a crucial driver of aggregate job creation and productivity growth; consequently, many countries devise policies to promote their formation and success. Recent research has highlighted the importance of startups' growth potential, and initial size, for their future performance. Sterk, Sedláček and Pugsley (2021), for instance, find that ex-ante factors explain a large share of the cross-sectional dispersion of employment even many years after firm entry. This form of ex-ante heterogeneity, however, is difficult – and costly – to observe; not only by researchers and policymakers, but arguably by startups themselves. Indeed, information frictions have been empirically shown to be one of the most sizable firm-level costs – see Zbaracki, Ritson, Levy, Dutta and Bergen (2004) – and firm managers' beliefs are consistent with models of information rigidity and inattention in particular, see Coibion, Gorodnichenko and Kumar (2018).

Motivated by these considerations, we build a model of startup creation with imperfect information, following the theory of rational inattention developed by Sims (2003). We show how rational inattention induces inefficient entry and labor misallocation, both in the form of under- and over-hiring relative to the first best of perfect information. We then document a novel information channel that alters the effects of lump-sum transfers to startups. While information frictions amplify the total employment effects of this policy, they generate three unintended consequences: transfers may amplify inefficient entry, reduce the initial size of most startups, and increase misallocation. By expanding the feasible set of choices, transfers alter the startups' learning problem and make them lean towards conservative hiring. We first isolate this new channel in a simple static model, and then explore how firm dynamics, financial frictions and other policies such as wage subsidies affect our conclusions. In these richer environments, the information channel dampens the intended effects of startup policies, and has markedly heterogeneous effects.

In light of the empirically documented importance of ex-ante heterogeneity, we focus our analysis on the very early stages of firm creation.[1] To this end, we begin with a deliberately simple static model in which potential entrants differ ex-ante in their idiosyncratic productivity. If firms decide to enter the market, they hire labor, which is the only factor of production, pay wages and a fixed cost. When information is complete, startups can observe their productivity beforehand, and the fixed cost implies that there exists a minimum level of productivity below which entry is not profitable. Moreover, all startups that enter the market hire optimally. When information is incomplete, however, rationally inattentive startups

[1] Therefore, we do not study learning over the entire firm life cycle, as instead done by Jovanovic (1982). We regard this channel as complementary to ours, especially in the context of the dynamic model discussed in Section 5.1.

only observe noisy signals about their true productivity. Learning is costly but endogenous and completely flexible, as firms decide which actions to learn about, the specific structure of the signals they aim to collect and how much information to acquire about the realization of productivity. Active learning implies that the quality of such noisy signals is chosen by the firm itself. Moreover, the full flexibility of information acquisition implies that there are no parametric assumptions on the distribution of signals chosen by startups. In this context, we study how rational inattention *simultaneously* affects the decision to enter the market and how many workers to hire.[2] Applying insights from Matějka and McKay (2015) and Caplin, Dean and Leahy (2019) to our framework, we add the discrete choice of firm entry, as an additional action, to the full set of employment choices.

Our parameterized model highlights two key implications of rational inattention. First, there is inefficient entry. Under imperfect information there is now a share of startups whose productivity is below the profitable cutoff but decide nevertheless to enter. Mistakes, however, happen also among profitable startups, some of which decide to stay out of the market although they would be making positive profits if they operated. Inefficient entry dominates, implying that more firms enter the market when information is not complete. These two effects push average productivity down. Second, rational inattention also distorts the intensive margin of hiring, which would instead be optimal with full information. Some startups over-hire relative to first best, while some under-hire. This generates a large dispersion in average and marginal products of labor, matching a ubiquitous feature of the data documented, for instance, by Bartelsman, Haltiwanger and Scarpetta (2013). Our results therefore echo David, Hopenhayn and Venkateswaran (2016), who theoretically and quantitatively show a sizable role of information frictions for misallocation.

We then use our theoretical framework to investigate how information frictions alter the effects of a homogeneous lump-sum transfer to startups. Policies of this sort are common across the globe. They often take the form of R&D grants, as studied by Howell (2017), but can also have a broader scope and loose requirements to meet.[3] The empirical evaluation of these policies, however, is particularly difficult, given the scarcity of identified exogenous variation and the limited observable information on startups, especially those that eventually do not enter the market. Moreover, some of these startup fundamentals, such as their growth potential, are likely to be imperfectly observed even by the entrepreneurs. We

[2] Woodford (2009) and Acharya and Wee (2020) study the extensive margin in isolation. The former in the context of firms' decisions to adjust existing prices, the latter in a search and matching framework where the decision to hire a worker is made under rational inattention.

[3] Caliendo and Tübbicke (2020) study a German start-up subsidy program targeted to the unemployed and show that similar policies are common in OECD countries. Such policies often come in the form of equity-free grants (e.g.: Start-up Chile, Bourse French Tech).

therefore see our model – and subsequent extensions – as a useful laboratory to outline the theoretical mechanisms that characterize the effects of startup policies, especially the allocative implications across the size and productivity distribution. Our framework also fits into a long-standing literature studying the consequences of policy when agents have imperfect information, such as Lucas (1972) and Woodford (2001). Under full information, the mechanism is simple: the transfer shifts the profitability cutoff to the left. It therefore increases entry, but leaves the intensive-margin hiring decisions of all startups unaffected.

We uncover three main unintended consequences of lump-sum transfers under rational inattention. First, while they generate an increase in firm entry three times larger than with full information, this amplification is driven by additional inefficient entry. Rationally inattentive startups do not observe the position of the profitability cutoff, but they know with certainty that some actions are dominated. The transfer makes some previously dominated actions feasible, shifting the perceived cutoff and boosting inefficient entry.

This channel lies at the core of the second unintended consequence: most startups *reduce* hiring when receiving a lump-sum transfer. The transfer adds newly feasible actions to the set of possible actions of startups. Due to the absence of regularity, typical of rational inattention models, the policy has an effect on the *entire* learning strategy and thus on the chosen employment distribution. The closer productivity is to the cutoff, the higher weight the potential entrant will put on the new, low-employment, actions made feasible by the transfer. A transfer equal to 5% of the fixed cost reduces average employment by 0.4%, among startups that would have already entered without the transfer. Finally, the lump-sum transfer increases misallocation, in the form of dispersion of marginal products of labor. This is caused by a reduction in information acquisition after the policy. Excessively large transfers are sometimes blamed for artificially keeping alive inefficient, "zombie", firms. We show how our novel information channel can lead to similar conclusions among young firms, as transfers may induce inefficient startups to enter the market and hire suboptimally.

The amplified effect along the entry margin, operating through enhanced inefficient entry, dominates the negative effects on initial size. As a result, transfers increase total employment of startups by more when information is imperfect. Importantly, most of the rich implications just discussed do not simply arise from generic information frictions; instead, they are the direct result of active learning under flexible information. Since startups tailor the characteristics of acquired signals, and these ultimately shape their actions, transfers alter both the learning and hiring strategies of the firm.

Next, we consider various extensions of the baseline model that make startup decisions richer and investigate how our conclusions are affected. First, startups may take into account an entire path of future expected profits when deciding to enter the market. To reflect this, we consider a two-period model in which operating firms pay a cost of adjusting labor between the first and the second period. Moreover, we assume that, after the first period, operating firms observe their productivity exactly. This framework reduces the extent of inefficient entry under rational inattention, but still generates a sizable exit rate even when productivity is fully observed. As such, information frictions appear to be consistent with empirically documented up-or-out dynamics, e.g., Decker, Haltiwanger, Jarmin and Miranda (2014). In addition, labor adjustment costs act as an "attention-grabbing" device, since the persistence in hiring decisions induces startups to pay more attention and learn more. As a result, labor misallocation is lower than in the static model, but more persistent, consistent with empirical findings on the negative relationship with firm age, Feng (2018). The model-generated persistence stems from uncertainty about ex-ante permanent heterogeneity and startups' mistakes made at the time of entry. Adding learning over the firm life cycle, as in Jovanovic (1982), would act as a complementary channel, further propagating these dynamics. In our two-period model, lump-sum transfers still display the unintended consequences previously described. However, they are now quantitatively less prominent – as startups have more to lose from a mistake – but more persistent over time.

We then augment this dynamic setting with financial frictions. Startups are typically limited in their ability to access external financing; indeed, grants and similar policies are often thought to operate via the relaxation of credit constraints that hamper startup creation and growth.[4] We assume that there is a cash-flow mismatch between the payment of the wage bill, which happens at the beginning of the period, and the realization of revenues, at the end of the period. We discuss various financial frictions that can affect startups' ability to satisfy this liquidity need and focus our analysis on earnings-based constraints, as recently studied by Drechsel (2019) and Lian and Ma (2021). With full information, lump-sum transfers not only stimulate firm entry, but now also boost hiring of financially constrained startups, since they improve their financial position.

The novel information channel previously discussed, and the associated unintended consequences, are however still present. The transfer increases inefficient entry, thus amplifying the entry margin effect relative to the full information benchmark, albeit to a lesser extent than without financial frictions. Along the intensive hiring margin, financially constrained startups face two counteracting effects. On the one hand, they want to increase employment, because they can borrow more. On the other hand, the transfer makes new, low-size, actions feasible; this alters startups' entire learning strategy and makes them lean towards less

[4] This channel is often discussed in the context of R&D grants to young firms, as in Howell (2017). Albert, Caggese and González (2020) study loan and wage subsidies in a model with heterogeneous firms, financial constraints and firm entry, and assess their effects during the COVID-19 recession.

hiring. The former channel prevails for higher-productivity firms, whereas smaller, unproductive startups choose a smaller initial size. On average, employment to cash flow elasticities are positive, but smaller than in full information. Hence, our theoretical framework provides an explanation for why cash transfers have been empirically found to have limited effects on startups' performance, see Howell (2020) and Gonzalez-Uribe and Leatherbee (2018). Their findings suggest that information frictions may be important for startups; we formally outline a mechanism through which information rigidities can affect the effectiveness of startup policies and work against well-known (financial) channels.[5]

Finally, we show how the negative information channel and its dampening effect on hiring decisions is present even with a different policy that subsidizes wages. Policy interventions of this type are common in many countries and have become even more popular during the COVID-19 pandemic. With full information, this policy not only stimulates firm entry, but it also boosts labor demand equally for all startups. Information frictions, instead, imply very heterogeneous effects. Productive startups benefit from the wage subsidy, increasing hiring to an extent similar to what observed with full information. Less productive firms, however, face two counteracting effects. On the one hand, the wage subsidy also boosts their labor demand. On the other hand, the shift in the productivity cutoff and the feasibility of previously dominated actions make them choose a lower initial size, operating through the mechanism previously described for the lump-sum transfer. This channel dominates only for very small startups, which reduce their labor demand in respond to the wage subsidy. On average, information frictions reduce the hiring effects of a wage subsidy relative to a full information benchmark; as such, our information channel can also be seen as a novel mechanism that lowers the own-wage elasticity of labor demand. On the other hand, information frictions amplify the total employment effects via higher inefficient entry, similarly to that obtained for lump-sum transfers.

The paper is organized as follows. In Section 2 we describe the baseline static model. Section 3 shows how rational inattention generates inefficient entry and suboptimal hiring. We present the effects of a startup transfer in Section 4. We then explore how our findings change in a dynamic model in Section 5.1, adding financial frictions in Section 5.2, and in response to a wage subsidy in Section 6. Finally, Section 7 concludes.

[5]Empirical work also highlights the effectiveness of non-monetary components of startup policies. We come back to this discussion, and its relation with information rigidities, in Section 5.3.

2 A model of startups

We consider a simple, one-period framework in which a unit measure of potential entrants chooses the amount of labor n to produce, among a discrete set of alternatives, and face decreasing returns to scale. The model is in partial equilibrium and zeroes in on the early stages of firm creation.

Potential entrants are heterogeneous with respect to idiosyncratic productivity z. With productivity z we have in mind any idiosyncratic fundamental that may introduce heterogeneity in performance across startups: for instance, demand components, productive efficiency, entrepreneurial ability, managerial talent. Given our focus on the early stages of firm creation, z aims to represent the form of ex-ante heterogeneity recently studied by Sterk et al. (2021) and Feliz, Karmakar and Sedlacek (2021), and shown to be a crucial driver of employment differences across US firms.

There is a finite amount of possible realizations for the idiosyncratic productivity, described by the set Ω_z. A hiring decision (i.e., an action) is a mapping from the potential productivity realizations to firm profits. Let Ω_n denote the set of possible actions, where $\pi : \Omega_n \times \Omega_z \to \mathbb{R}$ determines the firms profit of each hiring decision in each possible outcome for the productivity. Each unit of labor is paid at a competitive wage w. Every time a startup decides to enter the market, they must pay a fixed cost ϕ. We assume that the fixed cost is always known with certainty. Finally, τ is an exogenous transfer, which we set to 0 for now and later discuss in Section 4.

Profits of a startup i are defined as:

$$\pi_i = \begin{cases} z_i n_i^\alpha - w n_i - \phi + \tau & \text{if} \quad n_i > 0 \\ 0 & \text{if} \quad n_i = 0 \end{cases} \tag{1}$$

As noticed, the possibility of not entering the market is included in the set of possible actions and delivers zero profits.

We consider two possible states of the world, one in which startups have Full Information (henceforth, FI) about their idiosyncratic productivity $z \in \Omega_z$, and another where information is imperfect. In the latter case, we assume that, prior to making a hiring decision, startups can acquire costly information about z, following the theory of Rational Inattention (henceforth, RI).

2.1 Full Information

When information is complete, all potential entrants observe exactly z. Given the fixed cost ϕ, the optimal hiring decision is defined by a cutoff rule of productivity $n(\underline{z})$. Below this cutoff, startups do not enter because they make negative profits. Above this level, they choose an employment level that maximizes profits. Hence, our FI framework can be seen as a simplified version of Lucas (1978), where there is an observed distribution of managerial talent and the fixed cost can be interpreted as a fixed outside opportunity cost of managers' time.

Optimal employment with full information looks as follows:

$$n^*(z_i) = \begin{cases} \left(\frac{\alpha z_i}{w}\right)^{\frac{1}{1-\alpha}} & \text{if} \quad z_i^{\frac{1}{1-\alpha}} w^{\frac{\alpha}{1-\alpha}} \left(\alpha^{\frac{\alpha}{1-\alpha}} - \alpha^{\frac{1}{1-\alpha}}\right) \geq \phi - \tau \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

Therefore, $\underline{n} = \underline{z}^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{w}\right)^{\frac{1}{1-\alpha}} = \frac{\phi-\tau}{\alpha^{-1}-1} w^{\frac{-1-\alpha}{1-\alpha}}$ defines the minimum production scale.

2.2 Rational inattention

In the rational inattention problem, we assume that the firm imperfectly observes the idiosyncratic draw $z \in \Omega_z$. Information frictions have been shown to be one of the most sizable costs faced by firms. They affect firms' ability to observe their idiosyncratic fundamentals, such as demand and productive efficiency, see David et al. (2016), as well as adopting productivity-enhancing managerial practices, as in Bloom, Eifert, Mahajan, McKenzie and Roberts (2013). We believe that startups are no exception. In fact, it is even more likely to expect that potential entrepreneurs do not exactly observe their true ability/productivity before entering the market, or at least do not anticipate exactly how their own growth potential, z, will unfold. However, entrepreneurs have the incentive to acquire information about their growth prospects, and thus we employ a model that allows for endogenous learning.

Since z is imperfectly observed, profits associated to each possible action are ultimately unknown. It is possible to interpret the framework as one in which each prospective entrant only observes noisy signals about its true z, similarly to Clementi and Palazzo (2016). However, differently from their setup, signals are not drawn from an exogenous distribution, but startups actively choose the signal structure. Before choosing the amount of labor, the startup can collect information about the realization of z by designing an "information strategy", which consists of what specific information to learn and how much information to acquire. As we think about the information strategy as a set of signals, there is a stochastic mapping between the true productivity and these signals. The firm will, however, face a tradeoff. While more precise signals allow it to make fewer error-prone decisions (on average), a higher precision requires a higher cost. Following the literature on Rational Inattention, we measure this cost based on Shannon mutual information between signals and the unobserved productivity.

The startup decision problem under RI is given by a prior distribution $g \in \Delta(\Omega_z)$ over the set of possible values of productivity, the set of actions Ω_n and the marginal cost of information $\theta > 0$. An important implication of decision-making under RI is that for a strategy to be optimal, each possible action is selected by no more than a single posterior probability. Hence, each possible signal maps to just one possible action.[6] In turn, rather than choosing the possible quality of signals, we can merge the information and decision strategies into a single problem consisting of choosing the probability of each action in each state, as outlined in Matějka and McKay (2015) Corollary 1. Therefore, the firm chooses $F : \Omega_z \to \Delta(\Omega_n)$, i.e., the probability of $n \in \Omega_n$ in each possible state z. We denote $F(n|z)$ the probability of action n given z.

2.2.1 The hiring decision problem under RI

Startups choose F in order to maximize the expected value of profits minus the product of the marginal cost of information, θ, and the total amount of acquired information, κ. As standard in RI, κ is measured based on Shannon mutual information between states and actions. In particular:

$$\kappa \equiv -\sum_{n\in\Omega_n} F(n)\ln(F(n)) - \sum_{z\in\Omega_z} g(z)\left(\sum_{n\in\Omega_n} F(n|z)\ln(F(n|z))\right) \tag{3}$$

where $F(n) = \sum_{z\in\Omega_z} g(z)F(n|z)$ is the marginal probability of each possible action n. The first term on the right hand side of Equation (3) corresponds to the ex-ante (i.e.: prior to receiving information) uncertainty of the unconditional distribution $F(n)$ measured by its entropy.[7] The second term in Equation (3) corresponds to the ex-post (i.e.: after receiving new information) uncertainty of the posterior distribution $F(n|z)$.

The hiring decision problem of startups under RI is given by:

[6] Intuitively, if the agent chooses to receive different signals that lead to the *same* action, she will be acquiring costly information that is not ultimately used. See Lemma 1, in Matějka and McKay (2015).

[7] For a discrete distribution (as the one in this paper) with N equally possible realizations, the entropy is $\log(N)$. As N increases, each event becomes less likely and so entropy (uncertainty) increases.

$$\max_{F} \sum_{z \in \Omega_z} g(z) \left(\sum_{n \in \Omega_n} F(n|z) \pi(z, n) \right) - \theta\kappa \tag{4}$$

The fact that the final decision is drawn from $F(n|z)$ reflects the nature of the problem. Due to the imperfect information, the startup produces stochastic error-prone decisions. Full Information, in contrast, can be approximated by $\theta = 0$. In this world, for a given realized productivity z', the posterior probability would necessarily degenerate in the optimal decision $F(n'|z') = 1$, where n' is the FI hiring choice defined in Equation 2.

2.2.2 Optimal hiring decisions

Following Matějka and McKay (2015), the optimal hiring policy under RI must satisfy:

$$F(n|z) = \frac{F(n) exp(\pi(n, z)/\theta)}{\sum_{n' \in \Omega_n} F(n') exp(\pi(n', z)/\theta)} \tag{5}$$

The posterior probability is a function of the unconditional probabilities $F(n)$ and the normalized payoffs of each actions $exp(\pi(n, z)/\theta)$. Equation (5) then implies that each payoff is weighted by $F(n)$, which are by definition independent of the realization of z and the amount of information acquired. Hence, when a particular action n seems ex-ante very attractive (the firm is somehow predisposed to choose this specific action), then it has a relatively high probability of being chosen, although its actual payoff is low.

We can substitute Equation (5) in (4) to get an alternative formulation for the RI problem as a function of the unconditional probabilities:

$$\max_{F(n)} \theta \sum_{z \in \Omega_z} g(z) \left(\sum_{n \in \Omega_n} F(n) exp[\pi(z, n)/\theta] \right) \tag{6}$$

This alternative formulation is what we will use to solve the problem numerically. As one of the possible actions is to not enter the market ($n = 0$), this complicates the computational intensity of the problem greatly. By solving (6) instead of (4), we gain some numerical tractability, which allows us to solve for the two decision margins.

3 Firm entry under rational inattention

3.1 Parameterization

In order to show the main mechanisms operating in the model, we choose the following parameters. We set $\alpha = 0.8$. Given the partial equilibrium nature of the problem, the wage is normalized to 1. The fixed cost ϕ is chosen such that, under full information, 30% of the firms do not find it profitable to enter the market.

The information cost is set to $\theta = 0.0015$, equal to one fifth of the fixed cost ϕ. In spite of not being very large as a share of firms' labor costs, such information friction is nevertheless enough to imply sizable departures from the full-information outcome, while implying that most firms desire to acquire additional information.[8]

The productivity z_i of each potential entrant is drawn from a Gamma distribution with shape parameters $\kappa_g = 0.117$ and scale parameter $\theta_g = 0.193$. We choose the parameters to roughly match, under full information, the firm size distribution of startups in the US. We use data on newly born firms from the Business Dynamics Statistics (BDS) between 1977 and 2018. We target an average employment of 4.4, a standard deviation of 8.3, and a 75th and 90th percentile equal to 4 and 19 employees, respectively.[9] In implementation, we discretize the productivity space such that $|\Omega_z| = 1500$ and, hence, $|\Omega_n| = 1501$.

Finally, in our steady state we set the startup transfer τ to 0. We explore in Section 4 the effects of transfers to startups, i.e, $\tau > 0$.

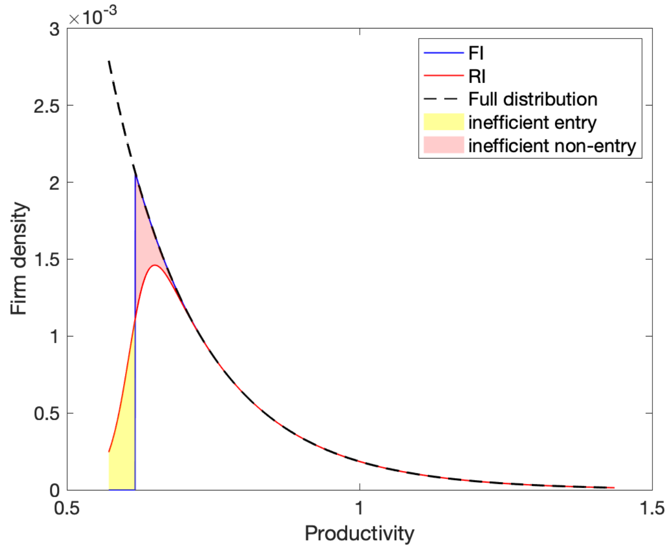
3.2 The distribution of startups with RI

In this section we illustrate how startups' entry and hiring decisions are affected by information frictions and the inability to know exactly their own productivity.

[8] As θ increases, acquired information quickly falls, soon achieving an equilibrium in which no firm decides to learn their productivity.

[9] Data averages over the sample period. The model-equivalent moments are 5.6, 8.4, 5.4 and 18.5, respectively. We drop startups with more than 100 employees, which account for 0.5% of all newborn firms and 18% of newborn aggregate employment. A very long right tail of the productivity distribution poses numerical challenges to the solution of our model. Moreover, our analysis is not focused on very large startups. Indeed, when exploring the effects of a transfer, we will show that these startups will not be very affected by the interaction between information frictions and entry decisions, and thus not central to the unintended consequences of startup transfers discussed in the paper. In the model implementation, we set the lower and upper bound of the grid for z such that, in full information, firms cannot be smaller than 1 employee and larger than 100.

Figure 1: Productivity distribution of entrants



3.2.1 (Inefficient) firm entry

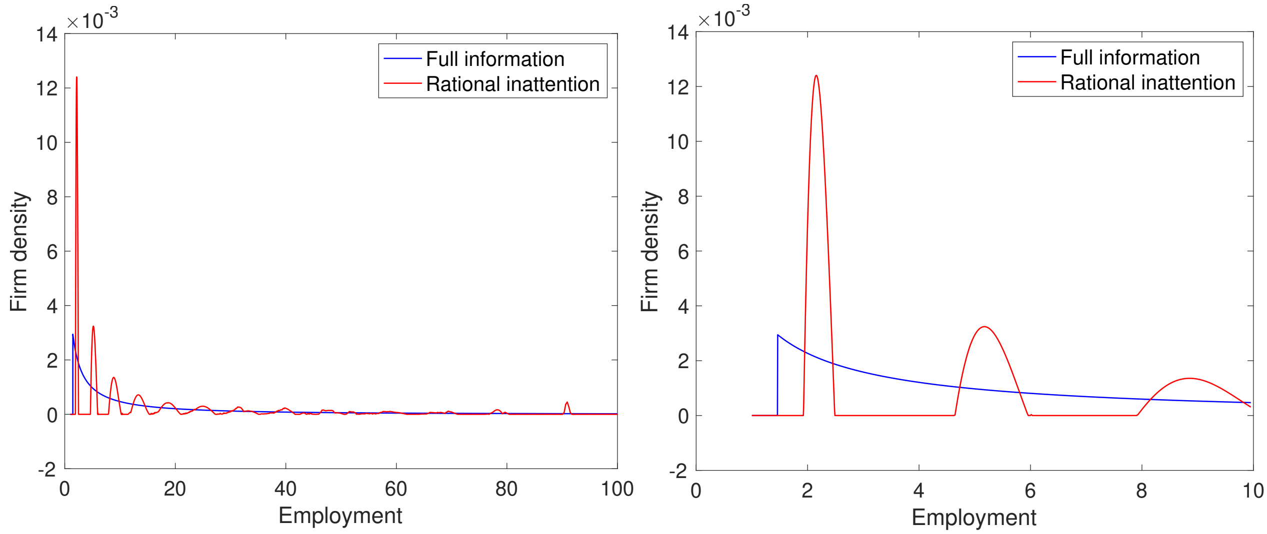
In Figure 1 we show the productivity distribution of startups that decide to enter the market. With full information, there is a clear entry cutoff (blue line in the figure); some states (z), below this cutoff, are never associated with a decision to enter the market. This latter result, in contrast, breaks down under rational inattention.

With FI, there is a one-to-one mapping between productivity and employment, both along the intensive (hiring) and extensive (entry) margin. In RI, this mapping is fuzzy and the sharp cutoff disappears, as shown by the red solid line. Some firms, whose productivity is so low that they should not enter, decide nevertheless to start up. Hence, RI generates inefficient entry. Moreover, some productive firms, which instead would enter if they observed their true productivity, do not hire any worker. Hence, RI implies inefficient "non-entry". As a result, the entrants' productivity distribution does not display a cutoff, but rather a continuous decay. In our parameterization, inefficient entry dominates, implying that information frictions boost firm entry. Moreover, both effects push average productivity down, by 1%. Finally, inefficient entry is empirically consistent with low survival rates of startups and the so-called "up-or-out" dynamics of young firms. We will come back to this point when discussing the two-period model.

3.2.2 Hiring decisions

We now explore how information frictions affect the intensive margin of hiring. In Figure 2 we show the employment distribution of startups under full information and under rational

Figure 2: Firm size distribution



(a) Entire distribution (b) Zoomed distribution

inattention.

Since z is observed (known) under FI, the size distribution of firms reflects the shape of the productivity distribution. This one–to–one mapping between z and n breaks under RI, and the firm size distribution degenerates into a few employment values.

The fact that RI brings discreteness in actions is an important result in this literature and has been formally proven by Jung, Kim, Matějka and Sims (2019). The intuition is that costly information forces the firm to focus only on a subset of actions, leaving the rest unconsidered. The hiring strategy of Figure 2 reflects the rationale behind the learning strategy of the firm and from which they will make their final hiring decision. Only actions with $F(n) > 0$ are finally considered by the firm as desirable choices. From Equation (6) we notice that the firm will chose $F(n)$ to maximize the transformed profits $\exp(\pi(z,n)/\theta)$ evaluated at prior beliefs $g(z)$. Through the chosen distribution for $F(n)$ we interpret that the firm aims to discriminate between nearly similar hiring levels that have the highest unconditional probability of occurrence: this is particularly apparent at the bottom of the size distribution. The convex transformation for the payoffs, however, also leads the firm to allocate some of its costly attention to high employment levels. As a result, the employment distribution shown in Figure 2a is more degenerate at the tails than in the middle.

Turning our attention to the left portion of the size distribution of startups, we have previously discussed how, in FI, there exists a productivity cutoff below which firms decide not to enter: i.e., $n^*(z) = 0$. As a result, there exists a minimum operating scale, $\underline{n}$, which pins down the minimum size of entrants. In other words, the subset of actions $\Omega_n^d \equiv (0, \underline{n})$

delivers a lower payoff – than alternative actions – for all realizations of z. Hence, it will never be selected by the firm. We label Ω_n^d as the set of dominated actions. While obvious under FI, through Equation (6) we notice that firms under RI will also ex ante remove Ω_n^d from the set of possible actions. In particular, if $n' \in \Omega_n$ is a dominated action, i.e. if $\pi(n', z) < \pi(n, z)$ for all z, the objective function can always be increased by shifting probability mass from $F(n')$ to $F(n)$. Hence, the set of *relevant* actions under both FI and RI is given by $n \in \Omega_n \setminus \Omega_n^d$. This result can be visualized more clearly in Figure 2b.

Following Caplin et al. (2019), we label the subset of hiring decisions that are chosen with positive probability Ω_n^c as the firm's *Consideration Set*. In particular $\Omega_n^c = \{n \in \Omega_n \setminus \Omega_n^d | F(n) > 0\}$. While under FI all possible firms' sizes are considered, the presence of imperfect information leads the firms to endogenously rule out some possible sizes ex-ante and focus on a small subset of alternatives. As a result, and in spite of the presence of inefficient entry, the minimum operating scale in RI is weakly larger than in FI.

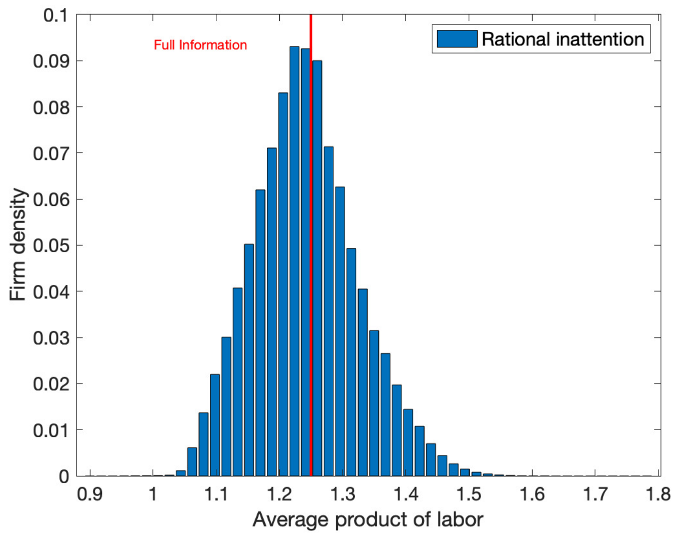
3.2.3 Misallocation

The fact that the minimum operating scale persists under rational inattention, while the minimum productivity does not, also has more subtle implications for misallocation and efficiency losses across firms. In our simple baseline model, conditional on entry, all firms choose employment optimally under FI, i.e., the marginal product of labor (MPL) is equal to the common wage. Therefore, there is no dispersion in MPL or in labor productivity, which is equal to $\frac{w}{\alpha}$. This is shown by the vertical red line in Figure 3. In the same figure we show that rational inattention introduces instead a large degree of dispersion in labor productivity. Even among entrants, firms do not exactly observe their productivity, thus breaking the one–to–one mapping with size. We find that some firms under-hire (MPL higher than the wage) with respect to the first best, while some other firms over-hire under RI (MPL lower than the wage). Together, this implies a large dispersion in the average and marginal products of labor, as documented in the data even within narrowly defined industries, for instance by Syverson (2004) and Bartelsman et al. (2013). Low average products of labor could be engineered in FI by introducing overhead labor in the production function.[10] Adding financial frictions instead, can generate under-hiring, which we discuss in Section 5.2. Interestingly, the information friction alone can endogenously generate both deviations at the same time.

We rationalize the observed dispersion with the idea of error-prone-decisions under RI. As previously mentioned, the mapping between actions and beliefs is stochastic, which reflects

[10] Output would be produced according to $y_{i,t} = z_{i,t}\,(n_{i,t} - \gamma)^{\alpha}$, where γ denote fixed expenses such as advertising and marketing. See, for instance, Bartelsman et al. (2013) for a discussion. In this case, even in FI, the MPL would always be equal to the wage, but the average product of labor would vary with firm size.

Figure 3: The distribution of the average products of labor



Notes: Average product of labor defined as the firm-level ratio of output y on employment n.

the intrinsic noise attached to the chosen signals. Although firms rationally choose the set of alternatives to maximize expected profits – i.e., the consideration set –, decisions are ultimately stochastic as they reflect the impossibility of perfectly observing z.

Hiring mistakes are also not evenly distributed across the productivity distribution. We find that productive firms typically under-hire relative to first best. In contrast, low-productivity firms over-hire. The intuition for this result builds on the minimum operating $\underline{n}$, which *censors* the possibilities of under-hiring for unproductive firms close to the cutoff. We show the quantitative extent of these hiring inefficiencies, and their correlation with productivity and size, in Appendix A.1.

4 Policy Experiment: a Startup Transfer

In this section we investigate the effects of a lump-sum transfer to startups. Policies of this type are common across the globe and take different forms; in particular, they often feature an equity-free cash infusion, which motivates our analysis.[11] We model this as a

[11] In section 5.3, we relate the theoretical channels discussed in this section with empirical evidence on cash grants to startups. In the simple version of the model discussed here, a transfer τ can also be interpreted as a reduction in the entry cost ϕ. Branstetter, Lima, Taylor and Venâncio (2014) find that a reform that decreased entry costs in Portugal boosted firm entry; however, startups were smaller, less productive and with lower survival probability. Our model is consistent with these facts.

Table 1: The employment effects of startup transfers

	% Change due to a 5% transfer	
	Full Info	Rational Inattention
Share of entrants	4.8	13.1
Average Employment	−3.4	−8.8
Average Employment (conditional on entry pre-transfer)	0	−1.5
Aggregate Employment	1.2	3.1

homogeneous monetary transfer equal to 5% of the fixed cost ϕ.

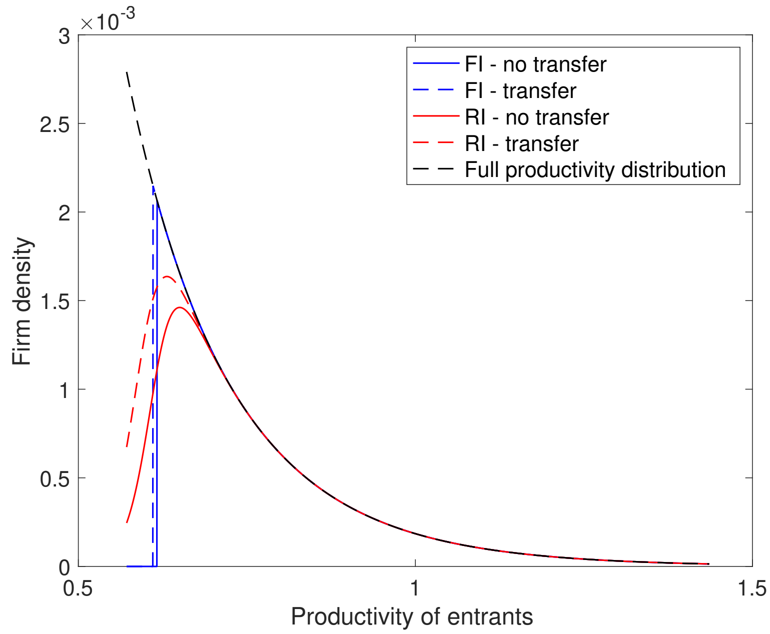
The effects of this policy when information is complete are straightforward. The transfer shifts the productivity cutoff to the left, making it profitable for more startups to enter the market. As a result, the average size of startups falls; startups that would have entered the market even without the transfer, however, do not adjust their employment decisions when receiving additional cash, since they are already operating at the optimal scale.[12] We summarize these effects in the FI column of Table 1.

Under rational inattention, however, even such a simple policy can have complex effects. First, although the FI productivity cutoff is not observed under RI, the presence of a lump sum transfer implies that firms are at least certain that the cutoff has "moved to the left". This brings along two relevant implications for the set of chosen actions. First, some actions that previously delivered negative payoffs now become more attractive because of the transfer. In other words, there is a subset of actions that is no longer dominated, hence they are added to the set of considered alternatives $\Omega_n \setminus \Omega_n^d$. Second, because of the shape of the prior distribution of productivity, the new set of added actions are unconditionally more likely to happen than already existing alternatives.

These two effects non-trivially affect the learning problem and, in turn, the hiring decisions. This is the result of two theoretical features of rational inattention, as studied by Matějka and McKay (2015): lack of regularity and monotonicity. The absence of regularity in RI problems implies that adding new alternatives to a choice set can alter the likelihood of existing alternatives being chosen. Such behavior is inconsistent with models of fixed attention, as well as with Random Utility Models. Rational inattention, in contrast, is consistent with such behavior because agents internalize the informational spillovers that arise from the addition of new objects to the choice set. Moreover, rationally inattentive agents attach greater unconditional probability of selecting actions that are relatively more

[12] We abstract from general equilibrium effects and assume that the wage is constant, under the assumption that the startups' contribution to aggregate employment is not big enough to meaningfully affect the aggregate wage.

Figure 4: Productivity distribution of entrants with transfer



attractive. This feature is known as the monotonicity of RI problems.

We summarize the employment effects of the transfer, under rational inattention, in the last column of Table 1. In the following subsections, we discuss in detail how information frictions alter the effectiveness of the transfer, disentangling its effects on the extensive margin (i.e.: the share of entrants), the intensive margin (i.e.: on already-entering startups) and misallocation.

4.1 Unintended consequences: extensive margin

Rational inattention amplifies the entry margin effect. 13.1% additional startups enter the market thanks to the transfer, nearly three times as many as with full information. Figure 4 explores the underlying sources of the adjustment. On the one hand, startup transfers reduce inefficient non-entry (i.e.: productive firms that should enter but choose not to) stemming from information frictions. On the other hand, they amplify information-related distortions by boosting inefficient entry (i.e.: low-productivity startups that should not enter). Put together, both effects amplify the effects on the extensive margin.

The intuition for these effects relies on the *perceived* position of the cutoff. Imagine a firm that before the transfer conjectures to have a low realization of z and then decides not to enter the market. The policy reduces the perceived distance between its belief about z and the cutoff, given the known reduction in $(\phi - \tau)$. As firms are certain that the cutoff moved to the left, more low-productivity startups decide to enter, although it is still not profitable to do so.

4.2 Unintended consequences: intensive margin

Let us now turn to the consequences for the intensive margin of hiring decisions. To do so, we focus on startups that entered even when $\tau = 0$. Under FI, those firms do not adjust employment in response to a lump-sum transfer, and therefore the intensive margin is zero, as reported in Table 1. Intuitively, τ does not enter the first order condition which governs labor demand. Under RI, however, the transfer generates a large dispersion in employment net gains. This is shown in Figure 5a. Some firms gain with the policy, but the vast majority loses.[13]

What lies behind these unintended consequences of startup transfers? We rationalize this result in light of the aforementioned absence of regularity in RI problems. Let us focus on the hiring decisions of a startup whose productivity is higher than the entry cutoff. In principle the lump-sum transfer should not affect its hiring decision. However, the new set of hiring alternatives introduced by the policy changes the information strategies for *all* firms. In particular, the added actions alter what to learn about and how much information to acquire. The higher unconditional probability of the newly added alternatives makes them very attractive, which pushes the firm to learn more about them while sacrificing learning about other (already existing) alternatives. Hence, as firms now focus more attention on these actions with lower employment levels, average employment drops by 1.5% with the policy, among firms that were already deciding to enter.

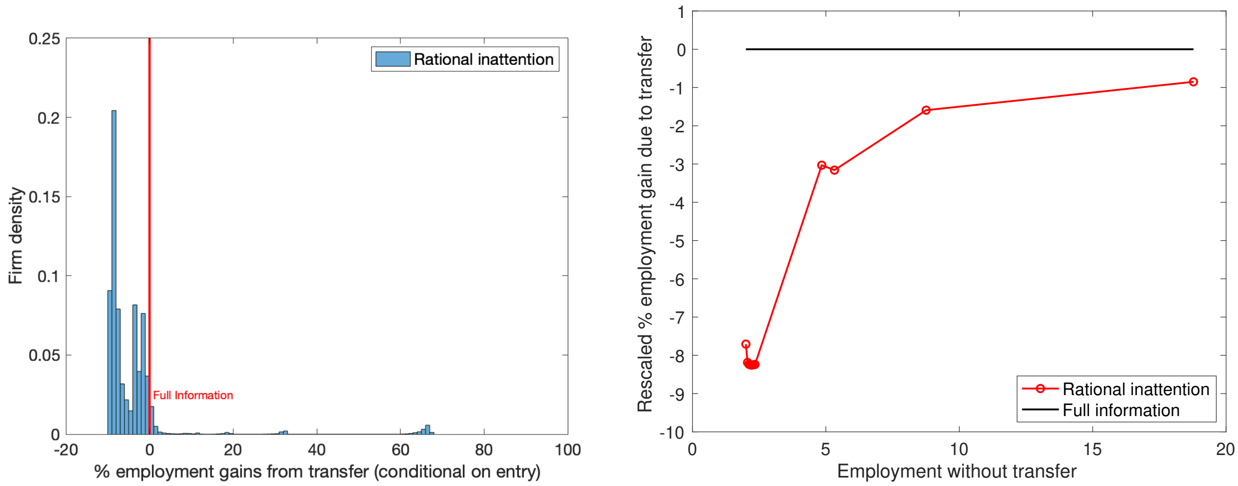
The information effect of the new alternatives, made feasible by the transfer, gradually fades away for larger, and thus more productive, startups. We show this in Figure 5b, which plots the median employment gains by quantiles of startups size. Small, unproductive startups typically lose from the transfer. As productivity increases, the negative effects gradually dissipate, although they persist even for large startups. These results highlight the gravity effect exerted by the newly added actions, which binds more the closer productivity is to the entry cutoff.

4.3 Unintended consequences: productivity effects

Finally, we turn to the productivity effects of the transfer, which we summarize in Table 2. Average productivity drops, even in full information, because less productive firms now

[13]To make sure that this is not the result of random error-prone decisions, our simulation ensures that, for each startup, the realization of productivity is the same with and without the transfer. The same applies to the random signal about z.

Figure 5: Employment gains from transfer: intensive margin



(a) Distribution of employment gains

(b) Employment gains by size quantile

Notes: 50 simulations of a panel of 100,000 firms. For each economy, we draw the same set of realized productivity shocks with FI and RI, with and without the transfer. We then restrict the attention to startups that operate even when $\tau = 0$. For this subset of firms, Figure 5a shows the distribution of percent employment gains due to transfer. In Figure 5b, we group entrants by deciles of their chosen size without the transfer. Each dot represents a decile; on the horizontal axis, we report the median size in the decile, without the transfer. On the vertical axis the within-decile median employment gains due to the transfer, rescaled by the median size. The figure plots averages across 50 simulations.

find it profitable to enter. Nevertheless, it drops more under Rational Inattention, because inefficient entry has increased when $\tau > 0$, as previously discussed.

Misallocation, measured by the standard deviation of MPL of entrants, increases in RI following the transfer, while it is obviously zero in FI. As shown in the last row of Table 2, and in line with the fact that the policy changes the learning strategies of the firm, total acquired information decreases relative to $\tau = 0$. Such behavior is consistent with findings by Mackowiak and Wiederholt (2012), who show that, under RI, agent facing limited liability processes less information than an agent with unlimited liability. In our framework the transfer bounds negative profits from below, which is qualitatively akin to a reduction in expected losses borne by the startup. As the subsidy crowds out information acquisition, error-prone decisions are amplified relative to the baseline scenario, leading to an increase in misallocation.

Our findings on inefficient entry and misallocation also relate to recent discussions on "zombie" firms. In particular, it may be possible that excessively high subsidies could keep inefficient firms artificially alive. The policies implemented in the aftermath of the COVID-19 pandemic have revived this debate, as discussed for instance by Zoller-Rydzek and Keller (2020). The literature has typically focused on policies that delay efficient exit of old and

Table 2: The productivity effects of startup transfers

	% Change due to a 5% transfer	
	Full Info	Rational Inattention
Average Productivity	-0.8	-2.1
St. Dev. MPL	–	3.7
Total acquired information	–	-5.3

unproductive firms. In contrast, we introduce a new (information) channel that affects young and unproductive firms; transfers might inefficiently push entrepreneurs to start up a firm and distort the efficient allocation of labor.

5 Extensions

The previous sections have showed how information frictions can give rise to unintended consequences of transfers to startups. To make this point cleanly, we have considered a simple, frictionless, static model. In this section we explore two natural extensions and investigate how our conclusions are affected. First, we extend the time horizon taken into account by startups and introduce labor adjustment costs. Second, we add financial frictions into this dynamic framework.

5.1 A two period model

Potential entrants arguably take into account expectations on many periods beyond the first when deciding whether to enter the market and at what initial size. Our baseline model can be reinterpreted as a multi-period collection of static problems, but doing so would not change any of the conclusions previously discussed. In order to illustrate how firm dynamics can affect the interaction between information frictions and responses to transfers, we therefore consider a tractable two period model.

As in the baseline model, each firm must choose its optimal size, but now the decision is taken over both the current ($t = 0$) and future period ($t = 1$), which we label as n_0 and n_1, respectively. The static profit function in period $t = 0$ is the same as in the static problem in Section 2. Startups discount the future at a rate $\frac{1}{\beta} - 1$ and, during the second period, all incumbent firms must pay a labor adjustment cost if they decide to modify n_1 relative to the previous size n_0. The cost of the size adjustment is given by $\gamma \left| \left(\frac{n_1}{n_0} - 1 \right) \right|$. We assume that productivity z is time invariant. Startups pay a fixed cost of entry, ϕ_0, in the first period, but they also face a lower operational cost $\phi_1 < \phi_0 - \tau$ in the second period.[14] We assume that the transfer is, however, only received in the first period.

Before entering the market, potential entrants indexed by i maximize discounted profits as follows:

$$\pi_i^* = \max\left\{\max_{n_{i0}}\left[\pi_{i0} + \beta\max\left\{\max_{n_{i1}}\left[\pi_{i1}\right], 0\right\}\right], 0\right\} \tag{7}$$

where $\pi_{i0} = z_i n_{i0}^{\alpha} - w n_{i0} - \phi_0 + \tau$ and $\pi_{i1} = z_i n_{i1}^{\alpha} - w n_{i1} - \gamma\left|\left(\frac{n_{i1}}{n_{i0}} - 1\right)\right| - \phi_1$. The discrete choice associated with 0 profits is achieved when the startup decides to not operate in that period (i.e., $n = 0$). When $n_{i0} = 0$, then $\pi_i^* = 0$. Indeed, no startup will choose to operate only in the second period, as this would deliver an infinite cost of adjusting labor. It could be, however, that $n_{i0} > 0$ and $n_{i1} = 0$, i.e., the firm decides to exit after the first period. In this case, $\pi_i^* = \pi_{i0}$. We come back to this case later.

The model is solved backwards. At the beginning of period 1, even under rational inattention, startups observe their productivity without any uncertainty. This is because, given n_{i0} and by observing period $t = 0$ profits, all surviving firms are able to back out their true level of productivity in period $t = 1$. The specific functional form for labor adjustment costs allows us to specify n_{i1} in closed form, conditional on chosen n_{i0}, as follows:

$$n_{i1}^* = \begin{cases} \left(\frac{\alpha z_i n_{i0}}{w n_{i0} - \gamma}\right)^{\frac{1}{1-\alpha}} & \text{if } n_{i1} < n_{i0} \text{ and } \pi_{i1} > 0 \\ n_{i0} & \text{if } n_{i1} = n_{i0} \text{ and } \pi_{i1} > 0 \\ \left(\frac{\alpha z_i n_{i0}}{w n_{i0} + \gamma}\right)^{\frac{1}{1-\alpha}} & \text{if } n_{i1} > n_{i0} \text{ and } \pi_{i1} > 0 \\ 0 & \text{if } \pi_{i1} < 0 \end{cases} \tag{8}$$

Under Full-Information, π_i^* is maximized when $n_{i1} = n_{i0}$. Hence, without the ex-ante uncertainty about productivity, the size of startups will remain constants over the periods.[15] This implies that the solution of the full information two-period problem is indeed equivalent to the one for the static problem introduced in Section 2.

Regarding the extensive-margin, in the second period, startups remain in operation as long as $\pi_{i1} > 0$. Similarly, FI startups decide to enter in the first period when their discounted

[14] Trade models of firm dynamics often assume the existence of an entry sunk cost ϕ_0 (paid once) as well as an operating fixed continuation cost $\phi_1 < \phi_0$ paid by the firm every period, see Alessandria and Choi (2007) or Ghironi and Melitz (2005) for an example.

[15] We can prove the above results by splitting the function π_i^* in two parts. Let $F(n_0, n_1) = z n_0 - w n_0 - \phi + \tau + \beta\left[z n_1^{\alpha} - w n_1\right]$; conditional on being positive, $F(n_0, n_1)$ is maximized at $n_0 = n_1 = \left(\frac{\alpha z}{w}\right)^{\frac{1}{1-\alpha}}$, i.e., a collection of static problems. Similarly, let $G(n_0, n_1) = -\beta\gamma\left|\left(\frac{n_1}{n_0} - 1\right)\right|$ which is also maximized when $n_0 = n_1$. Then, the function $\pi_i^* = F(n_0, n_1) + G(n_0, n_1)$ must be maximized when $n_0 = n_1$.

stream of profits is positive. Normalizing the wage to 1, and using the optimal FI hiring choice, the FI productivity cutoff in the second period is $\underline{z_1} = \left(\frac{\phi_1}{\alpha^{\frac{\alpha}{1-\alpha}} - \alpha^{\frac{1}{1-\alpha}}}\right)^{1-\alpha}$. When $z_i < \underline{z_1}$, startups will exit in the second period. This subset of firms would have entered in the first period if their productivity was above $\underline{\widetilde{z_0}} = \left(\frac{\phi_0 - \tau}{\alpha^{\frac{\alpha}{1-\alpha}} - \alpha^{\frac{1}{1-\alpha}}}\right)^{1-\alpha}$. However, since we assumed that $\phi_0 - \tau > \phi_1$, then $\underline{\widetilde{z_0}} > \underline{z_1}$, and therefore it cannot be that $z < \underline{z_1}$ and $z > \underline{\widetilde{z_0}}$, since productivity z is time-invariant. In other words, in full information, we set the entry and operational costs such that no startup will exit in the second period. In contrast, we will show how these implications change under rational inattention.[16] Finally, when productivity is higher than $\underline{z_1}$, we can obtain a closed-form productivity cutoff above which FI startups will decide to enter. This will be given by $\underline{z_0} = \left(\frac{\phi_0 - \tau + \phi_1}{(1+\beta)\left(\alpha^{\frac{\alpha}{1-\alpha}} - \alpha^{\frac{1}{1-\alpha}}\right)}\right)^{1-\alpha}$.

Let us now turn to the rational inattention problem. First of all, armed with the closed-form solution for optimal n_{i1}, we can write total profits as a function of n_{i0} and z only, and then solve the RI problem. Given the chosen functional form, we have seen that labor adjustment costs are inconsequential for the full-information solution. However, with RI, their presence implies that choosing the initial size incorrectly will have persistent consequences, as n_{i1} is a function of n_{i0}. For instance, a startup might choose an inefficiently low initial size n_{i0}, and then find it optimal to remain small in the second period, even after knowing z_i with certainty.

Information frictions also affect the entry-exit dynamics. We know from our static model that potential entrants will not be able to observe their position relative to the entry cutoff, given the noisy signals about their productivity. Moreover, in this dynamic framework, they will also imperfectly observe, in period-0, where they expect to stand relative to $\underline{z_1}$ in the following period. As such, some startups may enter in the first period and then decide to exit, after realizing that $z_i < \underline{z_1} < \underline{z_0}$. Likewise, although a group of startups may have made the mistake of entering in the first period ($z_i < \underline{z_0}$) they still can find it profitable to stay in the industry if its known productivity is above the new cutoff $\underline{z_1}$.

We set $\gamma = 0.01$, to allow for a small departure from the case where the two-period problem turns into a collection of static problems, i.e., $\gamma = 0$. Moreover, since we wish to isolate the effects of labor adjustment costs and forward-looking behavior, we keep θ equal to its original value in the baseline static model. We define $\phi_1 = \frac{2}{3}\phi_0$ and use the formula for

[16] We make the FI assumption to cleanly isolate how information frictions can be a source of up-or-out dynamics. In reality, many startups exit in the first years of their life, and this could be due to other (non–information) factors such as time-varying productivity and costs. For example, Hopenhayn (1992) studies firm entry and exit in a model in which potential entrants are ex ante identical but draw their productivity after entry, inducing some incumbent firms to exit.

$\underline{z}$ to recalibrate ϕ_0 such that 30% of potential entrants decide to operate in full-information. Finally, we set the discount factor $\beta = 0.95$.

5.1.1 Information frictions and forward-looking startups

First, we describe how startup decisions change in this dynamic environment, absent any policy. Broadly speaking, the main effects previously described remain: information frictions cause inefficient entry and misallocation. However, their quantitative importance changes. Moreover, these effects are now persistent over time.

Starting from the extensive margin, we now measure inefficient entry as the share of entering startups whose discounted stream of profits, defined by Equation 7, is negative. This fraction drops from 10% in our baseline static model to 4.8% in the dynamic framework, as entrepreneurs are more forward-looking and thus are less likely to enter when they should not. As discussed, since the fixed cost of operation is lower than the cost of entry (i.e., $\phi_1 < \phi_0$), no full-information entering startup decides to exit in the second period. This outcome, in contrast, takes place with information frictions: 1.6% of RI startups exit in the second period, roughly a third of the inefficient entrants.

The inefficient entry generated by information frictions translates into the up-or-out dynamics empirically documented, among others, by Decker et al. (2014). The dynamic framework implies that firm exit rates decrease with age, as observed in the data, and the model offers an explanation for these empirical patterns. Additional mechanisms, such as learning over the firm life cycle are then complementary to our channel. In particular, Jovanovic (1982) builds a model in which as firms spend more time producing in an industry, they progressively learn how to separate their inherent (time-invariant) productivity from the common random business fluctuations. This dynamic learning delays the process of exiting, whose persistence is disciplined by the assumed rate at which firms uncover their true productivity. In our framework, although firms can immediately back out their productivity in the second period, labor adjustment costs make the consequences of incomplete learning at the time of starting up long-lasting. Recent empirical evidence has supported the idea that it is the selection of skilled owners, rather than learning over the life-cycle of the firm, which determines the ultimate success of a startup, see Feliz et al. (2021). This is relevant for our model since, although we are abstracting from gaining business skills over time, the assumed dispersion in z_i allows us to capture time-invariant skills or specific owner characteristics, which are then crucial for the future of any startup.

The interaction between information frictions and labor adjustment costs also affects the intensive margin of hiring decisions. Adding the forward-looking component acts as an "attention-grabbing" device in the RI model: the persistence in the hiring decision forces the firm to learn more. The total acquired information is 26% higher than in the static model of Section 2. As a result, labor misallocation in the first period is lower than in the static model. However, it persists in the following period, even when productivity is observed by all startups, due to the labor adjustment cost. As for exit rates, the dynamic framework makes the relationship between misallocation and age less abrupt than in a repeated static model, in which the MPL dispersion disappears as soon as information frictions are lifted. Using data from China, Feng (2018) documents that the dispersion of marginal revenue products of capital falls with firm age, particularly before age 5. For instance, it is 5% lower for firms with 2 years of age compared to newborn. Our parametrized model generates a similar decrease for labor misallocation.

5.1.2 Startup transfers and forward-looking choices

Since a longer horizon makes entrepreneurs pay more attention to their unobserved productivity, it also reduces the unintended consequences of startup transfers that we have previously shown. In Table 3 we report the effects of this policy in a static and dynamic framework: moreover, to help comparability, we start focusing on the effects in the first period and discuss persistence later on.

Qualitatively, the main takeaways are maintained. Transfers boost inefficient entry when information frictions are present, therefore amplifying the effect along the extensive margin.[17] However, this amplification is smaller than in the static framework. Potential entrants take into account that a mistake can have consequences that persist over time; as such, they acquire more information and then are fooled less often by the leftward shift in the entry cutoff.[18] Similarly, while the transfer still lowers the average size of entrants, this effect is quantitatively less pronounced. Consistent with this, misallocation also increases but only half as much as in the static framework. Combining the entry and hiring margins, aggregate employment still increases more with information frictions, but to a lesser extent than in the static model.

While forward-looking behavior puts a drag on the unintended effects of transfers, it obviously makes them more persistent. For instance, startups are still 0.44% smaller with the transfer than without, in the second period, whereas such distortion would be erased entirely in a repeated static model.[19] In contrast, aggregate employment is still 0.9% above

[17] Since the structure of the model, and its parameterization, has changed, a 5% transfer to startups has a quantitatively different effect even under full information.

[18] With $\phi_1 = \phi_0$, the entry effect in FI is the same as in the static model. With RI it increases relative to Table 3, to 8.8%, but remains below the effects in the RI static model.

[19] Intuitively, lowering γ increases the intensive margin effect in the first period, relative to Table 3, and decreases it in the second.

Table 3: The effects of startup transfers: static vs dynamic

		% Change due to a 5% transfer			
		FI		RI	
		Static	Dynamic	Static	Dynamic
Share of entrants	$t = 0$	4.8	3.0	13.1	5.2
	$t = 1$		3.0		4.0
Average Employment	$t = 0$	0	0	-1.5	-0.5
(entrants with $\tau = 0$)	$t = 1$		0		-0.4
Aggregate Employment	$t = 0$	1.2	0.8	3.1	1.4
	$t = 1$		0.8		0.9
St. Dev. MPL	$t = 0$	–	–	3.7	2.9
	$t = 1$		–		1.2
Total acquired information		–	–	-5.3	-1.6

its level without transfer in the second period, due to the effects on entry.

5.2 Financial frictions

In the models outlined in the previous sections entering startups achieve the first-best employment level with full information. As a result, a startup transfer does not affect the hiring choices, absent any information friction. We have used this framework to cleanly show how, in contrast, information frictions distort hiring elasticities to the transfer.

It is reasonable to assume, however, that startups do not have unlimited access to funding. Introducing financial frictions implies that, even in the full-information scenario, transfers can be more expansionary, by making employment positively elastic to cash flow and thus boost startup hiring. Indeed, these policies are often thought to operate through a relaxation of financial constraints, see Howell (2017).

Therefore, in this section we augment the two-period model to allow for a very simple form of financial frictions, and show how it interacts with rational inattention and the effects of a transfer to startups. For simplicity, we assume that the financial constraint is only present in the first period. In order to maintain computational tractability, we assume that there is a cash-flow mismatch between the payment of the wage bill, which happens at the beginning of the period, and the realization of revenues, at the end of the period. This liquidity need can be fulfilled by raising external finance, which is however limited by a financial friction, see for instance Jermann and Quadrini (2012) and Melcangi (2018).

A first modeling option is to assume that potential entrants are endowed with a certain initial wealth, which can be pledged as collateral to obtain the intra-period loan used to pay for the wage bill. However, we find that this formulation implies little employment gains in response to the transfer. For any given level of initial wealth, startup choices are limited to a maximum level of employment: the transfer relaxes this constraint, but its quantitative effect is dwarfed by the negative information channel previously shown.[20]

We then turn our attention to earning-based constraints (EBC). In particular, we assume that the intra-period loan, $wn_0 - \tau$, is limited to be smaller or equal than a multiple of first-period profits. Earning-based covenants of this type have been shown to be ubiquitously present in the data and their modeling has been recently object of research in macroeconomics, for example Lian and Ma (2021) and Drechsel (2019). In particular, young and small firms are likely to depend on short-term loans and to be affected by EBC, see Caglio, Darst and Kalemli-Özcan (2021). It is interesting to note that the structure of the constraint can imply that, at least in full information, firms *below* a certain level of productivity are financially constrained. This feature makes the EBC substantially different from a constraint on initial wealth. As a result, the EBC implies a competing, positive, channel of the employment effects of the transfer, particularly affecting the same group of startups that suffer from the negative information channel previously discussed.[21]

Assuming, however, that a constraint of the form $wn_{i0} - \tau \leq \xi\pi_{i0}$ holds, implies a full revelation of uncertainty even under rational inattention after the first period. Consider, for instance, a low-productivity entrepreneur that is inefficiently entering the market under RI, as previously shown. When the EBC is present, the entrant exactly observes that she will receive a negative (or zero) loan. As a result, she immediately learns that her productivity z is associated with inefficient entry (i.e., negative profits) and thus refrains from entering.

In order to maintain the discussed effects of information frictions, such as inefficient entry, while also exploring their interaction with financial frictions, we consider the following model. We assume that startups can breach the EBC (i.e.: borrow more than a multiple of

[20]Since the constraint depends on a fixed and exogenous level of initial wealth, there is no internal propagation of the financial friction, through endogenous capital accumulation. We make this assumption to maintain the solution of the model computationally tractable: any endogenous state variable would make information decisions dynamic, as any information acquired in the current period would have implications for both the learning and the action strategies in the future. See Turen (2021) for an application of dynamic RI under flexible information. A financial friction where fixed initial wealth is used as collateral is also in line with evidence by Bahaj, Pinter, Foulis and Surico (2019), who find that small enterprises pledge directors' homes as the main source of collateral when obtaining a loan.

[21]Drechsel and Kim (2021) discuss how intra-period EBC can amplify pecuniary externalities in macroeconomic models. It is plausible to assume that, for some firms, EBC and constraints on wealth co-exist: given the limited role of the latter in our framework, as previously discussed, we abstract from this possibility.

their profits in the first period), but when they do so they incur a cost. This is a reduced-form approach to capture the empirical regularity that EBC and loan covenants are often breached.[22] Therefore potential entrants still maximize discounted profits as described in Equation (7); however, we now assume that the first period profits are:

$$\pi_{i0} = z_i n_{i0}^{\alpha} - w n_{i0} - \phi_0 + \tau - \eta \left(w n_{i0} - \tau \right)^{\sigma} \mathbb{1} \left(\left(w n_{i0} - \tau \right) > \xi \widetilde{\pi}_{i0} \right) \tag{9}$$

where $\widetilde{\pi}_{i0} = \max \left\{ z_i n_{i0}^{\alpha} - w n_{i0} - \phi_0 + \tau, 0 \right\}$. For simplicity, we show the results for $\eta = 1$ and $\sigma = 2$. A convex cost of this type can be reinterpreted as an interest rate on the intra-period loan that is linearly increasing with the size of the loan.[23] This specification effectively nests the standard EBC with an infinitely high η. Indeed, we numerically confirm that the extent of inefficient entry in RI decreases with η and σ. Following Drechsel (2019), we set $\xi = 4.6$.

Financial frictions imply that some low-productivity, constrained, firms choose a n_0 below its first best level even with full information. As a result, some startups will display an increasing employment schedule over time, as they trade off the financial cost in the first period with the labor adjustment cost in the second. We discuss next what happens under rational inattention.

5.2.1 The interaction between financial and information frictions

How does the financial friction interact with rational inattention? First, we look at the distribution of startups without the transfer, $\tau = 0$. Inefficient entry is still present, although it is now 4% of all potential entrants, down from 4.8% in the dynamic model without financial constraints. The financial cost further depresses negative profits of inefficient entrants, making them more aware of their mistake. In the limit, there is no inefficient entry if the financial cost becomes excessively high.

The financial friction implies that now there is labor misallocation also with full information. However, the dispersion of MPL is still twice as high with RI than without. Moreover, misallocation is one-sided with full information, as all constrained startups under-hire. In contrast, RI still generates over-hiring for 22% of startups. We report the distribution of MPL in Appendix A.2. Finally, financial frictions increase misallocation even with RI, as the dispersion of MPL rises by 15%. This is in spite of the fact that the EBC, and its associated

[22] While covenant breaches lead to technical default, in practice they can lead to various outcomes, including higher interest rates and substantial amendment fees, see Lian and Ma (2021) and Drechsel (2019). Chodorow-Reich and Falato (2017) show the widespread presence of covenant violations in the US during the Great Recession.

[23] Similar quadratic costs are often assumed in the corporate finance literature, for equity issuance and debt financing, see Bond and Söderbom (2013).

Table 4: The effects of startup transfers: financial and information frictions

		% Change due to a 5% transfer			
		FI		RI	
		Dynamic	Dynamic + EBC	Dynamic	Dynamic + EBC
Share of entrants	$t = 0$	2.99	3.30	5.19	5.17
	$t = 1$	2.99	3.30	4.00	4.65
Average Employment	$t = 0$	0	0.58	-0.47	0.07
(entrants with $\tau = 0$)	$t = 1$	0	0.56	-0.45	0.05
Aggregate Employment	$t = 0$	0.77	1.42	1.35	1.85
	$t = 1$	0.77	1.40	0.91	1.64
St. Dev. MPL	$t = 0$	–	-0.39	2.86	1.22
	$t = 1$	–	1.19	1.20	0.17
Total information		–		-1.63	-0.34

cost, induce startups to acquire more information.

5.2.2 Startup transfers under financial and information frictions

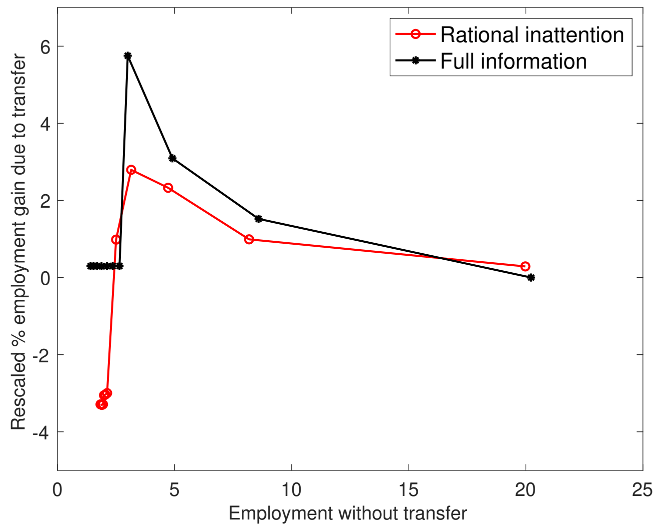
We then turn to the startup transfers considered in Section 4. The transfer now stimulates hiring, under full information, even among startups that would have entered the market with $\tau = 0$. This operates through two channels. First, a higher τ decreases the number of constrained firms, both by reducing the liquidity need and expanding the maximum amount beyond which borrowing is costly. Second, it lowers the borrowing cost for constrained firms.

How does this liquidity channel interact with rational inattention? We show how the negative information channel described in the previous sections, and the positive effects just described, co-exist and act in opposite directions. Table 4 summarizes the main results.

Starting from the extensive margin of entry, the EBC under full information plays a limited additional role. The transitory transfer increases the share of entrants in the first period, and such effect is permanent since the fixed operation cost in the following period is lower than the entry cost. As was the case without the EBC, entry increases by more when information frictions are present, driven by an increase in inefficient entry.

The most interesting interactions operate along the intensive margin. With full information, the transfer increases the average size of entrants, by relaxing the financial frictions. This effect persists over time due to the labor adjustment costs. Under rational inatten-

Figure 6: Heterogeneous employment gains from transfer



Notes: Same notes to Figure 5 apply, for the EBC model outlined in the text.

tion, this positive effect is still present. However, it co-exists with the negative information channel discussed in the previous sections and brought about by the fact that the transfer expands the set of available actions. Quantitatively, the former channel prevails and the transfer is now expansionary, even conditioning on entering startups.

The two counteracting channels have heterogeneous effects along the size distribution of startups, as can be seen in Figure 6. With full information, only firms below a certain productivity level (and thus size) are constrained. The smallest startups react little, because the transfer only affects their financial cost. Medium-sized startups are affected the most, because they are closer to the binding EBC; by affecting that margin, the transfer can result in sizable employment gains for these startups, as it makes them move to the unconstrained space. Largest startups are already unconstrained and thus unaffected by τ. The positive effect on medium-sized startups is still present under rational inattention, and more productive entrants are affected too since their decisions are error-prone. Smallest startups, however, are negatively affected by the transfer. These firms are the closest to the entry cutoff and therefore the most influenced by the addition of newly available feasible actions, as discussed in the previous sections. Nevertheless, this negative information channel is dampened by the forward-looking setting and, most importantly, the financial frictions; indeed, their employment losses are more than twice as small as what shown in Figure 5.

Combining the intensive and extensive margins, the aggregate employment effects of the transfer are still larger under rational inattention relative to full information, but the gap is smaller compared to the model without financial frictions. Misallocation still increases, driven by a fall in information acquisition, but this unintended consequence of the transfer is mitigated by the positive allocation effects stemming from a relaxation of financial frictions.

5.3 Discussion

Based on our theoretical analysis we are able to shed light on the empirical evidence on startup policies and identify the relevant channels through which they operate. The empirical evidence on lump-sum (equity-free) cash component of startup policies is scarce and mixed. On the one hand, cash grants alleviate financial constraints and have the ability to stimulate firm entry and growth, as shown by McKenzie (2017) in Nigeria. On the other hand, other recent studies find that cash transfers are broadly ineffective at boosting startups growth. For instance, Howell (2020) finds that cash prizes of venture capital competitions in the US have small effects on startups' performance. In contrast, certification of winners is the primary mechanism, suggesting that information effects play a crucial role. Similarly, Gonzalez-Uribe and Leatherbee (2018) find that the equity-free cash infusion granted by Startup Chile, a business accelerator, had no effect on startup scale and survival. The program, however, significantly enhanced the performance of the subset of startups that received entrepreneurship schooling.

In our model, this latter channel could operate in two ways. First, there could be programs that effectively increase entrepreneurial ability, z, for instance by building entrepreneurial capital, i.e., improving and developing the set of skills relevant to start a profitable business. González-Uribe and Reyes (2021), however, find that a cash-free business accelerator program in Colombia unlocked startups' potential but did not radically transform the startups' underlying growth fundamentals. In contrast, these programs seem to improve "firm capabilities"; in particular, they operate through channels of self-validation, making startups more aware of their true potential, but without radically changing their business ideas. As such, this would be equivalent to a reduction in the marginal cost of acquiring information in our model. Indeed, we have shown that full-information is associated with higher growth and lower misallocation.

More broadly, this empirical evidence suggests a crucial role for information frictions and the importance of taking them into account when assessing the effects of startup policies. Through the lens of our model, we have offered an information-driven explanation to the empirical finding that the effects of cash transfers, operating through a relaxation of financial constraints, may be limited. In the next section we show how this dampening also occurs with different policies that affect all startups' marginal costs.

6 Wage Subsidy

In this section we consider how inattentive startups respond to a wage subsidy. These policies are common worldwide and not limited to startups; moreover, they have become even more popular during the COVID-19 pandemic.[24] In practice, the policy experiment we consider in this section is a simplified way to gauge the many ways in which this type of policies are implemented, ranging from short-time work as in Giupponi and Landais (2018), to payroll tax cuts as in Saez, Schoefer and Seim (2019) and Ku, Schönberg and Schreiner (2020). In fact, we are going to show how information frictions alter (dampen) the own-wage elasticity of labor demand, whose empirical estimates in the literature have been recently summarized by Lichter, Peichl and Siegloch (2015).

From a theoretical perspective, this policy constitutes an interesting case study since, differently from lump-sum transfers, it affects both the extensive and the intensive margin of hiring even with full information. As such, we set out to explore how both margins interact with information frictions.

For the sake of comparison, we extend our baseline model of Section 2. When a firm decides to enter ($n_i > 0$), the static profit becomes $\pi_i^{ws} = z_i n_i^{\alpha} - w(1-\xi)n_i - \phi$, where $\xi \neq 0$ is the wage subsidy. We set lump-sum transfers τ to 0. With full information, the marginal productivity of labor for newborn firms always equals $w(1-\xi)$, thus all entering startups are better off with the policy as they can increase their profits by increasing their size. Moreover, the new optimality condition also affects entry as some previously unprofitable labor choices now deliver positive profits. Hence, under full-information the wage subsidy pushes small startups to enter while allowing all entrant firms to operate with a bigger scale relative to a scenario without such policy.

We consider a subsidy equal to 1% of the wage and summarize its effects in Table 5. As discussed, entry increases with full information. Such increase is, however, twice as large under rational inattention. This is the result of additional inefficient entry, working through the same channels discussed in Section 4.1. A wage subsidy moves the productivity cutoff to the left, but this effect influences the entry decision of many more entrepreneurs under rational inattention, as they observe only a noisy signal of their true productivity.

Turning to the hiring effects, conditional on entry, both models deliver a positive increase. Information frictions, however, dampen the extent to which the wage subsidy boosts labor demand. To show this, we have plotted in Figure 7 the distribution of percent employment

[24] The International Labour Organization (ILO) reports that at least 40 countries adopted temporary wage subsidies to prevent mass layoffs and preserve firm-worker matches (ILO Global Wage Report 2020/21). For further discussion on the effects of fiscal policy to SMEs during COVID-19, see Albert et al. (2020) and Gourinchas, Kalemli-Ozcan, Penciakova and Sander (2021).

Table 5: The employment and productivity effects of the wage subsidy

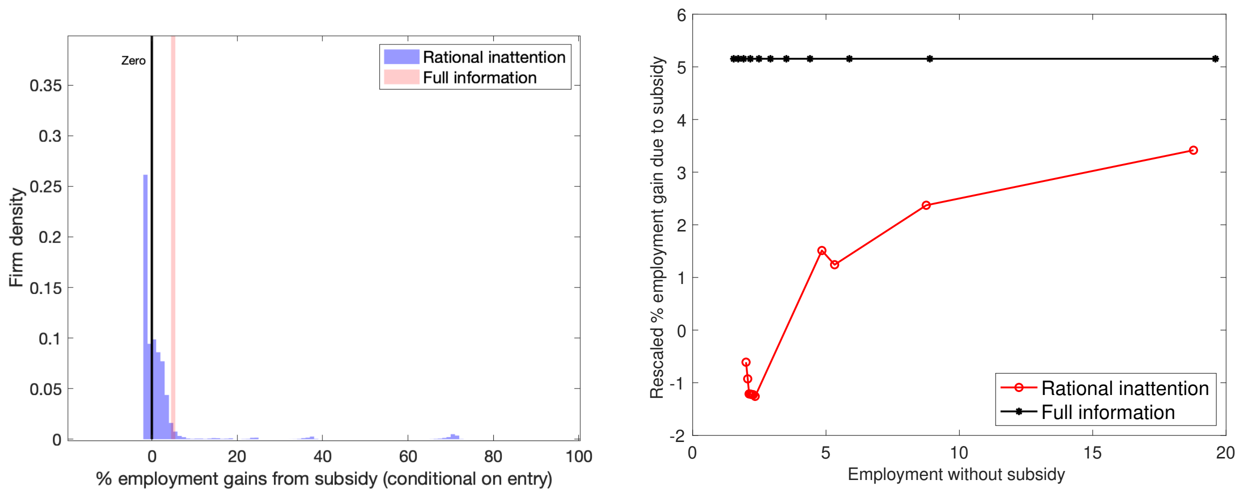
	% Change due to a 1% subsidy	
	Full Info	Rational Inattention
Share of entrants	3.9	8.6
Average Employment	2.2	-1.0
Average Employment (conditional on entry pre-transfer)	5.2	4.2
Aggregate Employment	6.2	7.5

gains due to the subsidy in the two models. With full information, all entrants increase employment by about 5% (precisely $\frac{1}{1-\alpha}\log(1-\xi)$). Employment gains with information frictions are, in contrast, more dispersed and typically below 5%. They are even negative for a third of the entrants. As was the case for the lump-sum transfer in Section 4.2, the fact that the wage subsidy lowers the productivity cutoff may induce startups to choose a lower initial size, by adding previously dominated low-size options to the set of feasible choices. This effect works against the positive employment effects from a lower marginal cost of labor. As we show in Figure 7b, the former channel dominates the latter for smaller, unproductive startups, which are closer to the cutoff. On average, the RI model therefore implies an own-wage elasticity of labor demand below what simply implied by the Cobb-Douglas production function, in line with the majority of empirical findings in the literature, as summarized by Lichter et al. (2015).

Combining the entry and intensive margin, aggregate employment increases following a wage subsidy, but more so under rational inattention. Moreover, differently from what observed with lump-sum transfers, misallocation is barely affected and marginally falls under this scenario.

To isolate how the intensive-margin effect of the wage subsidy operates in the model, we solve a model with no fixed cost ($\phi = 0$). In such framework, employment increases to a similar extent with and without information frictions, and there are no clear departures across the entire productivity distribution. Intuitively, the marginal cost is observed by all potential entrants, and therefore does not meaningfully interact with the information friction. In contrast, when $\phi > 0$, any effect on the unobserved productivity cutoff substantially distorts the entire learning problem and affects the whole distribution of startups.

Figure 7: Employment gains from wage subsidy: intensive margin



(a) Distribution of employment gains

(b) Employment gains by size quantile

Notes: We apply the same analysis of Figure 5 to the model with wage subsidy.

7 Conclusions

We have built a model that allows us to study how information frictions affect firm entry, as well as hiring choices of startups. Rational inattention is a source of empirically observed inefficient entry and misallocation, as inattentive startups do not observe exactly their own growth potential. Using this theoretical framework, we have documented a novel information channel that alters the effects of policies targeted at startups. Lump-sum transfers, such as equity-free grants, induce more firms to enter, as lower initial sizes are now profitable. This shift, however, is imperfectly observed by inattentive startups: as such, it alters the endogenous learning process, resulting in three unintended consequences: inefficient entry increases, productive startups choose a lower initial size, and misallocation goes up.

The negative information channel dampens the positive effects of transfers which arise from other frictions. For instance, we show that, in presence of labor adjustment costs, forward-looking inattentive startups are less prone to make mistakes. Financially constrained startups increase employment when receiving a transfer; rational inattention, however, lowers the employment to cash-flow elasticities, especially for small, unproductive startups. As a result, even when other frictions are present, information frictions imply that transfers boost total employment of startups by more, driven by an increase in inefficient entry, but positively affect startups' initial size by less. These conclusions hold also when considering wage subsidies, which do not only affect the firm entry margin, but also reduce all startups' marginal costs.

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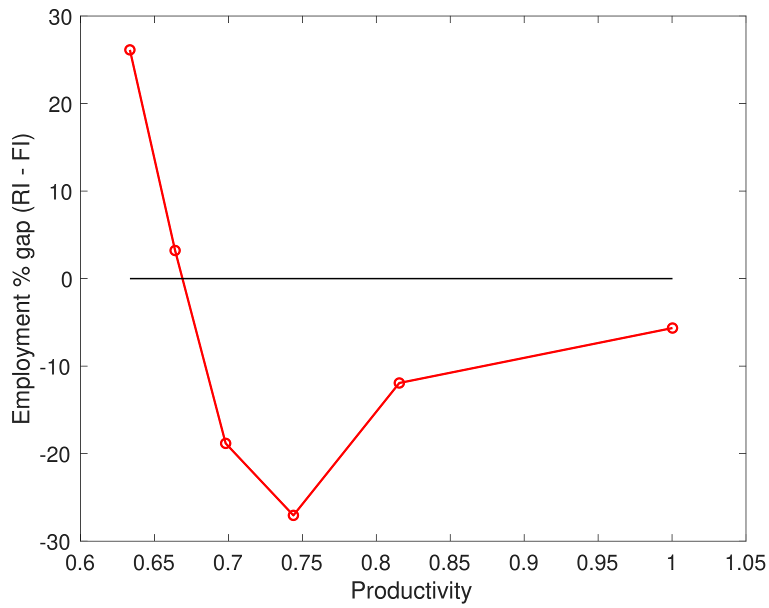
Figure 8: Under-hiring and productivity



Notes: We restrict the attention to firms that enter the market both in RI and FI, and construct quintiles of their productivity z. For each quintile, we plot average z on the horizontal axis, and the average % employment net loss in RI, relative to FI, within each quintile, on the vertical axis.

Appendix

A Supplemental results

A.1 Under-hiring and productivity in the baseline static model

In this section we revisit the employment inefficiencies under rational inattention for our baseline static model, as discussed in Section 3.2.3. Information frictions induce misallocation of labor, implying that some firms over-hire relative to first best, while others under-hire. Here we show that the RI-FI employment gap is not randomly distributed across the productivity distribution of entrepreneurs.

We consider quantiles of the productivity distribution. For each quantile, we compute the average of firm-level employment deviations between RI and FI. This is shown in Figure 8, where the dots represent each quantile.[25] To single out the intensive margin, we only focus on firms that enter both in RI and FI when computing the quantiles.

Recall that under RI, and for a given realization of z, the startup chooses n by drawing

[25]To make the comparison between FI and RI, we simulate a large sample of firms where each firm gets the exact same productivity draw z both under FI and RI.

from the posterior probability $F(n|z)$, equation (5), which is itself a function of the endogenously chosen alternatives $F(n)$. On the other hand, under FI, the distribution $F(n|z)$ would degenerate into a single action, i.e., the optimal n given z.

Let us start studying the implications for the most productive firms, towards the right end of Figure 8. It should be noted that, within each quantile, some firms under-hire and some others over-hire relative to the first best. This is due to the fact that productivity signals are randomly distributed around the truth. On average, however, productive startups under-hire. As we move toward less productive startups, under-hiring is more pronounced in percentage terms.[26]

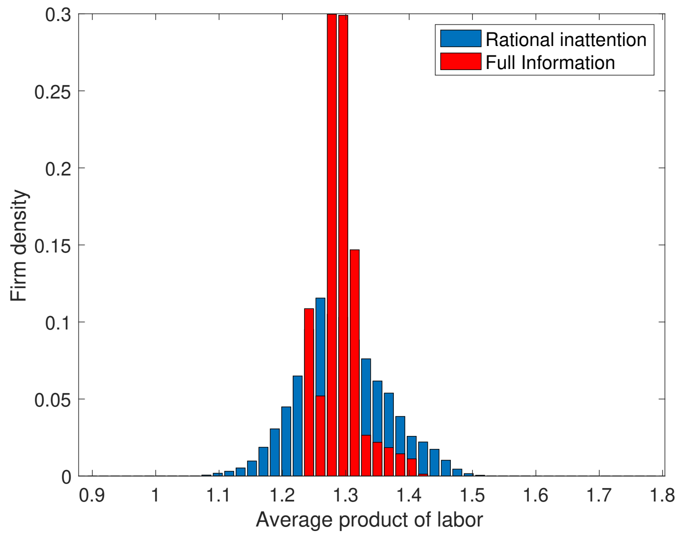
The relationship between employment gap and productivity sharply reverts for low-productivity firms. In fact, firms close to the productivity cutoff are more likely to be bigger in RI than in FI. In other words, over-hiring prevails on average in this case. The intuition for this result builds on the minimum operating scale $\underline{n}$, which *censors* the possibilities of under-hiring for unproductive firms close to the cutoff. In other words, a potential entrant whose productivity is perceived being very close to the cutoff knows, probabilistically (and thus, prone to mistakes), that it has more available hiring actions that are to the right of the first best action. Thus, this implies a tendency to over-hire for this particular group of firms.

A.2 Misallocation with information and financial frictions

In Figure 9 we show the distribution of average products of labor in the dynamic model with financial frictions presented in Section 5.2. The extent of misallocation is not only much larger under rational inattention, but its distribution is also quite different.

[26]The larger the productivity draw, the lower its likelihood: hence productive startups prefer to choose an employment level lower than in full information. This effect is reinforced by the concavity of the production function. Both channels, however, do not persist when looking at percentage deviations, as productive startups are also larger.

Figure 9: Misallocation with financial and information frictions



Notes: Average product of labor defined as the firm-level ratio of output y on employment n.