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# Discrimination, regulations and the optimal hiring process

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This article provides a theoretical framework for comparing two different hiring practices: an unpaid competitive internship that is followed by a potential job offer versus a standard series of interviews. After fully characterising the optimal hiring process, I show that high-ability minorities can be harmed by labour regulations that cause employers to shift towards a hiring process in which they are more likely to discriminate. Furthermore, preventing employers from giving truthful references is shown to exacerbate the obstacles to employment of a community traditionally facing discrimination.

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## 1 Introduction

It is an unfortunate feature of many modern economies that members of certain historically marginalised groups continue to face some form of discrimination when seeking employment, as evidenced by papers like Braddock and McPartland (1987), Goldin and Rouse (2000), Bertrand and Mullainathan (2004), Carlsson and Rooth (2007), Giuliano et al. (2009) and Heywood and Parent (2012). In the context of such employment discrimination, this article seeks to show how some labour regulations aiming to protect job applicants and interns can actually amplify the prejudices faced by members of these communities.

An important part of the literature on economics has been on the matching process between employees and employers. However, relatively little work has been done on the optimal hiring process itself. The standard hiring practice consists of conducting a series of interviews to acquire information about potential employees in order to get the right match. An alternative to this method is the *try before you buy* (see Coco, 2000) approach of internships: two interns compete for a job and the company hires the most productive intern. Given these two options, this article seeks to model the optimal hiring process, as well as to model the fundamental trade-off between these two processes.

To achieve these aims, a framework is developed with one principal and two agents. An agent can be of either a low- or high-productivity type, and an agent's type is his private in-

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formation. The principal wishes to hire one of the agents, preferably a high-productivity type, to conduct a project in which profits are distributed among the hired agent and the principal according to two exogenously given shares. The principal has the choice between two hiring processes. First, he can choose the investigation process, where he spends some resources in order to acquire a set of signals about the agents' types. This can be thought of as the traditional series of interviews applicants go through when applying for a job. Second, the principal can choose the internship process, where the two agents compete for the job through an internship tournament. However, the principal has some prejudice towards one of the agents who belongs to a marginalised group, which subsequently hurts the agent's chances of being hired. (An agent's association with a favoured or marginalised group is public information.)

I find that the optimal hiring process is based on a fundamental trade-off between the accuracy of the signals and their costs. I also show that if the investigation's signals are sufficiently precise, then the investigation process is more likely to be optimal when the difference between a low-productivity worker and a high-productivity worker is high. This suggests that highly productive employees are more likely to be hired through the investigation process if the firm has access to a sufficiently competent recruiting department. Additionally, I show that banning unpaid internships and discouraging negative references from previous employers can amplify the discrimination faced by marginalised workers, even though both policies aim to protect labourers. I conclude by discussing how these results relate to the 'ban-the-box' debate (see Agan and Starr, 2018; Doleac and Hansen, 2020).

An alternative application for this framework would be to compare a setting where entry-level workers face an up-or-out scheme to a setting where a firm fills a position with external hires. However, a consequence of this alternative application would be that one of the agents would face discrimination at the 'promotion stage' instead of the 'candidate stage'. Given that the labour regulations on internships and previous employers' references studied in this article revolve around the 'candidate stage', I will focus on applying this framework to the optimal hiring process instead of the optimal promotion process. For similar reasons, discrimination that would occur at an earlier hiring stage (filtering applicants for interviews and internships) is not the area of focus of this paper (see Knouse et al. (1999) for evidence of racial differences in internship attainment).

Some papers in organizational economics have approached the hiring problem by focusing on the idiosyncratic features of the firm. For instance, Lazear (2009) showed that workers are more valuable at some firms than others based on employer valuation. Lazear (2000) showed that incentive pay attracts more skilled applicants, as potential workers self-sort. Other papers such as Anderson et al. (2009), Hayes et al. (2006) and Woodcock (2015) have focused on the importance of getting the best match between the employee and workers. Another approach has been to focus on the signals agents can send about their type to potential employers (see Spence, 1973; Lazear, 1986). Autor (2001) and Autor and Scarborough (2008) concentrate on the role that labour market intermediaries can have in smoothing the hiring process, while papers like Fernandez and Weinberg (1997), Holzer (1987), Montgomery (1991) and Saloner (1985) argue for the importance of referrals and networks of current employees to screen applicants. Macroeconomic conditions can also affect hiring decisions (see Russo, Gorter and Schettkat, 2001), and the choice between hiring employed or unemployed workers is studied by Fallick and Fleischman (2004) and Tranaes (2001). This article build upon frameworks with one principal and two agents with limited signalling abilities, in order to focus on how the optimal hiring process can generate the greatest amount of information for employers[1].

Multiple papers sought to model (see Phelps, 1972) or provide a rationale for discrimination with or without using prejudice as an assumption. Milgrom and Oster (1987) argue that the skills of disadvantaged workers are harder to uncover for firms, which then keep high-skilled disadvantaged workers in low-paying jobs to hide their type from other employers. Tirole (1996) models discrimination as a consequence of the noisy signals firms receive on potential workers' types. Firms then react to this noisy signal by complementing it with the stereotypes surrounding the applicant's group. Bernhardt (1995) develops a framework where classes of workers differ in their skill distribution and, even with the absence of discrimination, shows that less able workers from the dominant population receive opportunities before more able workers from the dominated group. Focusing instead on firings, Oyer and Schaefer (2000) show evidence that methods of firing changed differently by race following the civil rights acts of 1999, while Oyer and Schaefer (2002) demonstrate that the returns to experience varied across groups during the same time period. Casella and Hanaki (2006) and Casella and Hanaki (2008) study the optimal hiring process by comparing referral-based versus certification hiring structures and highlight the dominance of the referral-based process and the subsequent consequences for discrimination.

Since the causes of employment discrimination are beyond the scope of this article, I assume a form of prejudice that reconciles the premise of rational profit-maximising employers with the existence of discrimination to link certain labour policies to a potential amplification of employment discrimination.

## 2 Preliminaries

### 2.1 Model Framework

*Preferences.* This framework consists of one principal and two agents. All three players are risk-neutral. An agent's type is defined by his cost parameter, which can only take two possible values $\theta_i \in \{\theta_L, \theta_H\}$, with $\theta_L < \theta_H$. The principal needs to hire one of the agents to conduct a project and prefers to hire a type-L agent. The principal wants to choose the optimal hiring process in order to maximise his chances of hiring a type-L agent and maximise his profits

[1] See Oyer and Schaefer (2011) for a more complete literature review on the subject of hiring in economics.

while providing an expected utility for each agent of at least their reservation utility, which is assumed to be 0.

*Information Structure and Group Affiliation.* Each agent learns his type after entering either of the hiring processes outlined below, but the principal and the other agent never fully do so. Furthermore, one of the agents is affiliated with a marginalised group, meaning the principal is prejudiced against this agent, who might subsequently be discriminated against during the hiring decision (the exact form of discrimination is described below), while the other agent is from a favoured group that is safeguarded from this discrimination. The share of H-type agents is $\frac{1}{2}$ in each group, and the agents' types are drawn independently from one another. These two facts and the agents' group affiliation are public information.

*Hiring Processes.* The principal can hire the agents through an internship process or an investigation process. During the internship process, each agent competes in a tournament and the winner of the internship tournament is potentially revealed to the principal. During an investigation process, the principal conducts his own research about the agents' types and potentially unveils the agents' types. Each hiring process is described in detail in section 2.2. In either case, the principal gets some signals concerning the agents' types and hires the agent who he believes is the most likely to be an L-type agent[2].

*Discrimination.* In both hiring processes, the principal can receive either an unambiguous signal (which sends a clear, unmistakable message about the agents' types) or an ambiguous signal (which is open to interpretation). During the internship process, the principal receives an unambiguous signal with probability (1-p) indicating who won the internship tournament and receives, during the investigation process, an unambiguous signal with probability (1-q) indicating the result of his research. However, when receiving an ambiguous signal, which happens with probabilities $p$ and $q$ in the internship and investigation processes, respectively, the signals are open to interpretation, in which case the principal discriminates against the agent from the marginalised group by hiring the agent from the favoured group. It should be noted that the principal's prejudice is consequential only after receiving an ambiguous signal: it is irrelevant following a clear unambiguous signal about the agents' type[3]. This kind of prejudice reconciles the premise of employers being rational profit-maximisers (this prejudice does not decrease expected profits) while still allowing for discrimination.

*Production Technology and Payoffs.* Once an agent is hired, he will exert an effort $e_i$ with $i \in \{L, H\}$ at a cost $\frac{\theta_i e_i^2}{2}$ in order to influence the outcome of the project. The payoffs of this project are drawn from a distribution with a mean of $\eta e_i$, where $\eta$ is a revenue component that is independent of the agent's type. The expected revenue $\eta e_i$ is distributed between the principal,

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[2]This setup excludes the possibility of the principal spending resources to acquire a more precise signal about the agents' type, akin to Autor (2001).

[3]This is similar to a simplified form of Fryer et al. (2019), in which an agent's bias would disappear in the limit of a perfectly informative signal.

who gets $\alpha\eta e_i$, and the hired agent, who gets $(1-\alpha)\eta e_i$. The profit share $\alpha$ is taken as exogenous by all players. The hired agent's problem is

$$\max_{e_i} \quad (1-\alpha)\eta e_i - \frac{\theta_i e_i^2}{2}, \tag{1}$$

with a resulting first-order condition of $e_i^* = \frac{(1-\alpha)\eta}{\theta_i}$. Therefore, during the project stage, the hired agent of type $i \in \{L, H\}$ receives an expected payoff of $\frac{(1-\alpha)^2\eta^2}{2\theta_i}$, while the principal gets $\frac{\alpha(1-\alpha)\eta^2}{\theta_i}$. The agents are protected by a limited liability constraint preventing the principal from asking the agents for upfront payments, side contracts between the agents are not feasible, and the principal is contractually obligated to pay the hired agent's share of the overall profits.

*Timing.* The timing of the game is as follows. First, the principal chooses between the investigation process or the internship process. If the internship process is chosen, then the agents learn their types and exert some effort in the hopes of winning the internship tournament. If the principal receives an unambiguous signal indicating the winner of the internship tournament, then he hires that agent. If he receives an ambiguous signal, then he hires the agent from the favoured group. If the investigation process is chosen and the principal receives an unambiguous set of signals, then he receives two signals, one for each agent's type, updates his prior beliefs about the agents' types and hires the agent he believes is the most likely to be a type-L agent. If he receives an ambiguous set of signals, he once again hires the agent from the favoured group. Finally, the hired agent now has to exert some effort in a project in which returns are distributed among the principal and himself.

## 2.2 The Expected Profits of Both Processes

### 2.2.1 Internships

If an internship process is chosen at a cost $S$ to the principal, then each agent is tasked with producing the highest possible value $y_i = \tilde{e}_i + \epsilon_i$. Agent $i$ directly controls his effort $\tilde{e}_i \in \mathbb{E} \subset \mathbb{R}$ but has no control over the noise $\epsilon_i$. For tractability purposes, I assume $\epsilon_1 - \epsilon_2 \sim U[-L, L]$. At this stage, if agent $i$ is from the marginalised group, his problem is

$$\begin{aligned}
&\max_{\tilde{e}_i \in \mathbb{E}} \frac{(1-\alpha)^2\eta^2}{2\theta_i}\text{Prob(winning)} - \frac{\theta_i \tilde{e}_i^2}{2} \\
&\qquad = \max_{\tilde{e}_i \in \mathbb{E}} \frac{(1-\alpha)^2\eta^2}{2\theta_i}[(1-p)\text{Prob}(\tilde{e}_i + \epsilon_i > \tilde{e}_{-i} + \epsilon_{-i})] - \frac{\theta_i \tilde{e}_i^2}{2} \\
&\qquad\qquad = \max_{\tilde{e}_i \in \mathbb{E}} \frac{(1-\alpha)^2\eta^2}{2\theta_i}[(1-p)(\frac{\tilde{e}_i - \tilde{e}_{-i} + L}{2L})] - \frac{\theta_i \tilde{e}_i^2}{2},
\end{aligned} \tag{2}$$

which results in a first-order condition of

$$\tilde{e}_i^* = \begin{cases} \frac{(1-\alpha)^2\eta^2(1-p)}{4L\theta_i^2} & \text{if } L > \frac{(1-\alpha)\eta[(1-p)(\theta_i^2-\frac{1}{2}\theta_{-i}^2)]^{\frac{1}{2}}}{2\theta_i\theta_{-i}} \\ 0 & \text{otherwise.} \end{cases}$$

The condition on the parameters ensures that agent i has a positive expected utility from entering the internship process[4]. If agent $i$ is from the favoured group, his problem is

$$\max_{\tilde{e}_i \in \mathbb{E}} \frac{(1-\alpha)^2\eta^2}{2\theta_i}[(1-p)(\frac{\tilde{e}_i - \tilde{e}_{-i} + L}{2L}) + p] - \frac{\theta_i \tilde{e}_i^2}{2}, \tag{3}$$

which also yields a first-order condition of

$$\tilde{e}_i^* = \begin{cases} \frac{(1-\alpha)^2\eta^2(1-p)}{4L\theta_i^2} & \text{if } L > \frac{(1-\alpha)\eta[(1-p)(\theta_i^2-\frac{1}{2}\theta_{-i}^2)]^{\frac{1}{2}}}{2\theta_i\theta_{-i}} \\ 0 & \text{otherwise.} \end{cases}$$

I make the parameter restrictions given below:

$$L > \frac{(1-\alpha)\eta[(1-p)(\theta_H^2 - \frac{1}{2}\theta_L^2)]^{\frac{1}{2}}}{2\theta_H\theta_L}. \tag{4}$$

Assumption 4 ensures that type-H agents, and therefore all agents, regardless of type or group affiliation, exert a positive level of effort during the internship process, even if the other agent is of type L. The principal only observes who created the highest $y_i$, so he can receive two possible unambiguous signals:

$$s_i \in \{\text{Agent 1 wins}, \text{Agent 2 wins}\} \equiv \{s_1, s_2\}. \tag{5}$$

I introduce the following notation for convenience: denote the type of both agents by $\theta = (\theta^1, \theta^2)$ and write $\theta_{LL} = (\theta_L^1, \theta_L^2)$, $\theta_{LH} = (\theta_L^1, \theta_H^2)$, $\theta_{HL} = (\theta_H^1, \theta_L^2)$ and $\theta_{HH} = (\theta_H^1, \theta_H^2)$. Given his prior beliefs, the principal believes that $P(\theta = \theta_{LL}) = P(\theta = \theta_{HH}) = P(\theta = \theta_{LH}) = P(\theta = \theta_{HL}) = \frac{1}{4}$. Assuming that the principal will receive an unambiguous signal, the probabilities of the principal receiving signal $s_i$ conditional on the agents' type are

$$\begin{aligned} P(s_1|\theta_{LL}) = P(&\frac{(1-\alpha)^2\eta^2(1-p)}{4L\theta_L^2} - \frac{(1-\alpha)^2\eta^2(1-p)}{4L\theta_L^2} \geq \epsilon_2 - \epsilon_1) \\ &= P(0 \geq \epsilon_2 - \epsilon_1) = \frac{1}{2}, \end{aligned} \tag{6}$$

[4]The inequality can be obtained by entering $\tilde{e}_i^*$ into agent i's expected utility (see (2)) and solving for the set of parameters that ensures that it is strictly positive.

$$P(s_1|\theta_{HL}) = P(\frac{(1-\alpha)^2\eta^2(1-p)}{4L\theta_H^2} - \frac{(1-\alpha)^2\eta^2(1-p)}{4L\theta_L^2} \geq \epsilon_2 - \epsilon_1) = \frac{1}{2} - \frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2-\theta_L^2)}{8L^2\theta_H^2\theta_L^2} \quad (7)$$

and

$$P(s_1|\theta_{LH}) = P(\frac{(1-\alpha)^2\eta^2(1-p)}{4L\theta_L^2} - \frac{(1-\alpha)^2\eta^2(1-p)}{4L\theta_H^2} \geq \epsilon_2 - \epsilon_1) = \frac{1}{2} + \frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2-\theta_L^2)}{8L^2\theta_L^2\theta_H^2}. \quad (8)$$

For similar reasons, it can be seen that $P(s_1|\theta_{HH}) = P(s_2|\theta_{LL}) = P(s_2|\theta_{HH}) = \frac{1}{2}$, $P(s_2|\theta_{LH}) = \frac{1}{2} - \frac{(1-\alpha)^2\eta^2(\theta_H^2-\theta_L^2)}{8L^2\theta_H^2\theta_L^2}$ and $P(s_2|\theta_{HL}) = \frac{1}{2} + \frac{(1-\alpha)^2\eta^2(\theta_H^2-\theta_L^2)}{8L^2\theta_L^2\theta_H^2}$. Therefore, after receiving some unambiguous signal $s_i$, the principal's posteriors are

$$P(\theta_{LL}|s_1) = P(\theta_{HH}|s_1) = P(\theta_{LL}|s_2) = P(\theta_{HH}|s_2) = \frac{1}{4}, \quad (9)$$

$$P(\theta_{LH}|s_1) = P(\theta_{HL}|s_2) = \frac{1}{4} + \frac{(1-\alpha)^2\eta^2(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2} \quad (10)$$

and

$$P(\theta_{HL}|s_1) = P(\theta_{LH}|s_2) = \frac{1}{4} - \frac{(1-\alpha)^2\eta^2(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}. \quad (11)$$

From these posteriors, it can be seen that if the principal receives the unambiguous signal $s_i$, he will hire agent $i$, believing that he is the most likely to have the smallest cost parameter:

$$P(\theta^1 = \theta_L|s_1) = P(\theta^2 = \theta_L|s_2) = \frac{1}{2} + \frac{(1-\alpha)^2\eta^2(\theta_H^2-\theta_L^2)}{16L^2\theta_H^2\theta_L^2} \quad (12)$$

and

$$P(\theta^1 = \theta_L|s_2) = P(\theta^2 = \theta_L|s_1) = \frac{1}{2} - \frac{(1-\alpha)^2\eta^2(\theta_H^2-\theta_L^2)}{16L^2\theta_H^2\theta_L^2}. \quad (13)$$

If the principal receives an ambiguous signal, he hires the agent affiliated with the favoured group. In the event of an ambiguous signal, the principal expects the same profits from hiring either agent, so applying the principal's prejudice does not decrease his expected profit. The principal's expected utility is then

$$
\begin{aligned}
p[(\frac{1}{2})&\frac{\alpha(1-\alpha)\eta^2}{\theta_L} + (\frac{1}{2})\frac{\alpha(1-\alpha)\eta^2}{\theta_H}] \\
&+ (1-p)(\frac{1}{2}\{[\frac{1}{2} + \frac{(1-\alpha)^2\eta^2(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}]\frac{\alpha(1-\alpha)\eta^2}{\theta_L} \\
&+ [\frac{1}{2} - \frac{(1-\alpha)^2\eta^2(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}]\frac{\alpha(1-\alpha)\eta^2}{\theta_H}\} \\
&+ \frac{1}{2}\{[\frac{1}{2} + \frac{(1-\alpha)^2\eta^2(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}]\frac{\alpha(1-\alpha)\eta^2}{\theta_L} \\
&+ [\frac{1}{2} - \frac{(1-\alpha)^2\eta^2(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}]\frac{\alpha(1-\alpha)\eta^2}{\theta_H}\}) - S \\
&= [\frac{1}{2} + \frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}]\frac{\alpha(1-\alpha)\eta^2}{\theta_L} \\
&+ [\frac{1}{2} - \frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}]\frac{\alpha(1-\alpha)\eta^2}{\theta_H} - S, \quad (14)
\end{aligned}
$$

where the first line represents the principal's expected profits, should he receive an ambiguous signal, and the second to fifth lines represent what would happen if the principal received an unambiguous signal that agent 1 won and the hired agent was of type $\theta_L$ or of type $\theta_H$ (second and third lines) or received an unambiguous signal that agent 2 won and the hired agent was of type $\theta_L$ or of type $\theta_H$ (fourth and fifth lines). Once simplified, the sixth line represents the expected utility of hiring the internship winner who turns out to be type L, and the seventh line represents the expected utility of hiring a type-H winner.

### 2.2.2 Investigations

In this setting, the principal can acquire a set of signals $(\phi^1, \phi^2)$ at some cost $E$. The signals indicate $\phi^i \in \{\theta_L, \theta_H\}$, with

$$P(\phi^i = \theta_L|\theta^i = \theta_L) = P(\phi^i = \theta_H|\theta^i = \theta_H) = \sigma \qquad \forall i \in \{1,2\}, \quad (15)$$

$$P(\phi^i = \theta_L|\theta^i = \theta_H) = P(\phi^i = \theta_H|\theta^i = \theta_L) = 1-\sigma \qquad \forall i \in \{1,2\}, \quad (16)$$

where $\sigma > \frac{1}{2}$ can be seen as the precision of the signal. More specifically, with probability $\sigma(1-\sigma)$, the principal will receive a correct signal about one of the agents, but an incorrect signal about the other agent. With probabilities $\sigma^2$ and $(1-\sigma)^2$, the principal receives two correct and incorrect signals, respectively. This implies that when the principal receives some unambiguous signal $\phi^i$, his posterior beliefs become

$$P(\theta^i = \theta_H|\phi^i = \theta_H) = P(\theta^i = \theta_L|\phi^i = \theta_L) = \sigma \qquad \forall i \in \{1,2\}, \quad (17)$$

$$P(\theta^i = \theta_L | \phi^i = \theta_H) = P(\theta^i = \theta_H | \phi^i = \theta_L) = 1 - \sigma \qquad \forall i \in \{1, 2\}. \tag{18}$$

Suppose that the principal receives an unambiguous signal. Given that the share of H-type agents is $\frac{1}{2}$ in each group and the agents' types are drawn independently from one another, the principal expects with probability $\frac{1}{4}$ the $(\phi^1 = \theta_H, \phi^2 = \theta_L)$ signal, at which point he would update his beliefs to $P(\theta^1 = \theta_H|\phi^1 = \theta_H) = P(\theta^2 = \theta_L|\phi^2 = \theta_L) = \sigma$ and $P(\theta^1 = \theta_L|\phi^1 = \theta_H) = P(\theta^2 = \theta_H|\phi^2 = \theta_L) = (1 - \sigma)$. Since the principal will hire agent 2, he expects the payoff $\sigma\frac{\alpha(1-\alpha)\eta^2}{\theta_L} + (1-\sigma)\frac{\alpha(1-\alpha)\eta^2}{\theta_H}$, which would be based on his posterior beliefs. The principal can also receive the signal $(\phi^1 = \theta_L, \phi^2 = \theta_H)$ with probability $\frac{1}{4}$, which would yield the same expected utility. Should the principal receive signal $(\phi^1 = \theta_L, \phi^2 = \theta_L)$, which can occur with probability $\frac{1}{4}$, the principal would be indifferent concerning hiring either agent. In any hiring decision, his expected utility would continue to be $\sigma\frac{\alpha(1-\alpha)\eta^2}{\theta_L} + (1 - \sigma)\frac{\alpha(1-\alpha)\eta^2}{\theta_H}$. Finally, should the principal receive with probability $\frac{1}{4}$ the $(\phi^1 = \theta_H, \phi^2 = \theta_H)$ signal, the principal would also be indifferent concerning hiring either agent but would expect a payoff of $\frac{1}{4}\sigma\frac{\alpha(1-\alpha)\eta^2}{\theta_H} + (1 - \sigma)\frac{\alpha(1-\alpha)\eta^2}{\theta_L}$.

Therefore, the principal's expected utility is

$$\begin{aligned} q[(\frac{1}{2})\frac{\alpha(1-\alpha)\eta^2}{\theta_L} + (\frac{1}{2})\frac{\alpha(1-\alpha)\eta^2}{\theta_H}] \\ + (1-q)\{\frac{1}{4}[\sigma\frac{\alpha(1-\alpha)\eta^2}{\theta_H} + (1-\sigma)\frac{\alpha(1-\alpha)\eta^2}{\theta_L}] \\ + \frac{1}{4}[\sigma\frac{\alpha(1-\alpha)\eta^2}{\theta_L} + (1-\sigma)\frac{\alpha(1-\alpha)\eta^2}{\theta_H}] \\ + \frac{1}{4}[\sigma\frac{\alpha(1-\alpha)\eta^2}{\theta_L} + (1-\sigma)\frac{\alpha(1-\alpha)\eta^2}{\theta_H}] \\ + \frac{1}{4}[\sigma\frac{\alpha(1-\alpha)\eta^2}{\theta_L} + (1-\sigma)\frac{\alpha(1-\alpha)\eta^2}{\theta_H}]\} - E \\ = \frac{\alpha(1-\alpha)\eta^2}{\theta_H}[\frac{2-(1-q)(2\sigma-1)}{4}] \\ + \frac{\alpha(1-\alpha)\eta^2}{\theta_L}[\frac{2+(1-q)(2\sigma-1)}{4}] - E, \end{aligned} \tag{19}$$

where the first line represents the expected utility should he receive an ambiguous signal and the second to fifth lines are the sum of the principal's expected utility should he receive an unambiguous signal (see the previous paragraph for a full breakdown of these components).The sixth and seventh lines are the simplified form of the principal's expected utility.

Finally, to ensure a non-trivial environment where the principal does not randomly hire a worker (does not use the internship or investigation processes), either

$$\frac{\alpha(1-\alpha)\eta^2(\theta_H - \theta_L)(2\sigma - 1)}{4\theta_L\theta_H} > E \tag{20}$$

or

$$\frac{\alpha(1-\alpha)\eta^2(\theta_L + \theta_H)}{2\theta_L\theta_H} + \frac{\alpha(1-\alpha)^3\eta^4(1-p)(\theta_H^2 - \theta_L^2)(\theta_H - \theta_L)}{16L^2\theta_H^3\theta_L^3} > S \tag{21}$$

must hold to ensure that the internship process or the investigation process is more profitable than randomly selecting a worker. In other words, the benefits of using either hiring process are worth the costs. Given the absence of costs for the agents and their reservation utilities of zero, the participation constraints of all agents in the investigation process are respected.

## 3 The Optimal Hiring Process

I denote the accuracy of the signals generated by the internship and investigation processes by $V_{\text{Int}} \equiv \frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}$ and $V_{\text{Inv}} \equiv \frac{(1-q)(2\sigma-1)}{4}$ and the profits they generate by $\Pi_{int}$ and $\Pi_{inv}$, respectively. Furthermore, I will now refer to the difference between the agents' types $(\theta_H - \theta_L)$ as the returns to information. First, I fully characterise the optimal hiring process using the parameter space. I then look at how the returns to information impact the optimal hiring process.

**Proposition 1**

**i)** If $E = S = 0$, then the investigation process yields a higher expected profit if and only if $V_{\text{Inv}} \geq V_{\text{Int}}$.

**ii)** The investigation process yields a higher expected profit than the internship process if and only if $\sigma > \sigma^* \equiv \frac{1}{2} + \frac{\alpha(1-\alpha)^3\eta^4(1-p)(\theta_H^2-\theta_L^2)(\theta_H-\theta_L)+16(E-S)L^2\theta_H^3\theta_L^3}{8(1-q)L^2\theta_L^2\theta_H^2\alpha(1-\alpha)\eta^2(\theta_H-\theta_L)}$.

**iii)** A decrease in $\theta_L$ favours the investigation process if and only if $\sigma > \sigma^{**} \equiv \frac{1}{2} + [\frac{(1-\alpha)^2\eta^2(1-p)}{4(1-q)L^2}](\frac{3\theta_H^2-\theta_L^2-2\theta_H\theta_L}{2\theta_H^2\theta_L^2})$. Similarly, an increase in $\theta_H$ favours the investigation process if and only if $\sigma > \sigma^{***} \equiv \frac{1}{2} + [\frac{(1-\alpha)^2\eta^2(1-p)}{4(1-q)L^2}](\frac{2\theta_H\theta_L+\theta_H^2-3\theta_L^2}{2\theta_L^2\theta_H^2})$.

Taken together, results 3.1-i:iii show that the optimality of either hiring process depends on a fundamental trade-off between the accuracy of the signal sent by both processes and its cost: if the precision of the internship process (the inverse of $L$) is sufficiently high relative to that of the investigation process ($\sigma$), then the internship process is the most profitable and therefore the optimal one (and vice versa). If the principal incurred no cost in either process, then this comparison would simply boil down to the accuracy of each process. Intuitively, results 3.1-i:iii suggest that the hiring process should be judged solely on the information generated about potential candidates and the costs of doing this.

An influential determinant in the optimal hiring process is the returns to information, or the difference between $\theta_H$ and $\theta_L$, which can change through either parameter. Its impact can be divided into two separate effects. First, there is the signal effect, which simply alters the accuracy of the internship signal. This occurs because agents have more (less) motivation to work in an internship process, since they are more (less) likely to be judged based on their work rather than blind luck, following an increase (decrease) in the returns to information. Second, there is the information effect, whereby a variation in the returns to information alters the returns to hiring a worker of type $\theta_L$ instead of $\theta_H$.

When combined, these effects favour the investigation process if and only if the accuracy of the investigation process is sufficiently large. This suggests that more productive workers are more likely to be hired through the investigation process if and only if a firm has access to a sufficiently competent human resources department or an external recruitment firm.

It should be noticed that the threshold associated with a decrease in $\theta_L$ is larger than the threshold associated with an increase in $\theta_H$. This happens because an increase in $\theta_H$ inflicts an additional profit loss on the internship process through the noise channel. This implies that the accuracy of the investigation process has a smaller threshold to beat in order to guarantee that it is the process that is favoured by an increase in $\theta_H$. Conversely, a decrease in $\theta_L$ provides an extra benefit to the internship process, implying $\sigma$ needs to be above a higher threshold for this variation to favour the investigation process.

# 4 Labour Regulations and Discrimination

## 4.1 Main Results

Up until now, the agents' expected utilities have received little attention. It is straightforward to see that the agents incur a cost in the internship process that is non-existent in the investigation process (the cost of exerting $\tilde{e}_i$ without any compensation). Furthermore, one hiring process potentially exposes the marginalised workers to more discrimination given the different probabilities of the principal receiving an ambiguous signal ($q$ and $p$). Proposition 4.2 argues that within such an environment, certain labour policies can inadvertently exacerbate the problems faced by some marginalised workers, by making it optimal for employers to switch to a hiring process they dislike.

More specifically, one can think of a minimum wage policy for interns. The proponents of such a policy would argue that banning unpaid internships would advance workers' rights. Within this framework, such a policy would force the principal to pay the losing intern a minimum wage $w$. I argue below that if this minimum wage is sufficiently high (see $w'$ in proposition 4.2-i below), then this policy can actually hurt marginalised workers. Additionally, proposition 4.2-ii exposes that in extreme cases, marginalised workers might actually prefer a higher likelihood of discrimination. Finally, proposition 4.2-iii argues that labour regulations, which aim to protect workers by making it harder for previous employers to provide negative references (thereby increasing the ambiguity of the investigation process), can hurt marginalised employees.

**Proposition 2**

**i)** Suppose that $\Pi_{int} > \Pi_{inv}$ holds and that the government can now impose a minimum wage $w > 0$ for interns. If the government imposes a sufficiently large $w'$ (see (22) for the explicit definition) and if $\frac{(1-p)(\theta_L+\theta_H)[8L^2\theta_L\theta_H-(1-\alpha)^2\eta^2(1-p)]}{4L^2\theta_L\theta_H[\theta_L(3-2e)+\theta_H(1+2e)]} > (1-q)$ holds (meaning a marginalised worker prefers the internship process), then this labour policy would convert the investigation process into the optimal hiring process, thereby hurting marginalised workers.

**ii)** Assuming the optimal hiring process remains the internship process, increasing the ambiguity of the internship process $p$ is beneficial to both the favoured and marginalised workers if $(1-p) \geq \frac{4L^2\theta_L\theta_H}{(1-\alpha)^2\eta^2}$.

**iii)** Assuming that the optimal hiring process remains the investigation process, increasing the ambiguity of the investigation process $q$ always hurts the marginalised workers.

Result 4.2-i is interesting because it suggests that labour regulations that discourage or outright ban unpaid internships can actually harm some of the workers they aim to protect, especially in the context of widespread discrimination. The threshold $w'$ represents a level of internship wages for agents that is so costly to the principal that he would no longer find the internship process the optimal hiring structure. Supposing that the aforementioned public policy establishes a sufficiently high minimum wage for interns ($w > w'$), this would push employers towards using the investigation process. Through the channel highlighted in result 4.2-i, this would hurt marginalised workers, assuming they prefer the internship process.

Similarly, in an attempt to protect employees' reputations from malicious previous employers, governments might be tempted to establish a tight legal framework regulating what previous employers can say when contacted for work references. However, given the increased threat of lawsuits created by these policies, the end result might be that the response from employers would be to never make any negative comments about previous employees. Within this framework, such a policy would simply increase the likelihood of an ambiguous signal during the investigation process, by increasing $q$. Result 4.2-iii argues that the impact of this policy on marginalised workers would be to increase the discrimination they face, since they would become more likely to be evaluated through a discriminatory channel than before. This is in line with several papers, such as Agan and Starr (2018) and Doleac and Hansen (2020), on 'ban the box'[5] (BTB) literature, where labour regulations aiming to protect workers exacerbated racial discrimination. In fact, Agan and Starr (2018) showed that the black-white gap for callbacks following online applications grew by a factor of six following the BTB regulations.

Result 4.2-ii highlights that highly skilled workers would prefer more ambiguous signals if distinguishing themselves from low-skilled workers was sufficiently costly. This counterintuitive result suggests that discrimination is simply another cost with which marginalised workers have to deal. This solely happens in the internship process, due to the absence of costly efforts for the agents in the investigation process.

[5]The 'ban the box' policy aims at easing the reinsertion of ex-offenders into society by removing the box ex-offenders have to check when applying for a job.

### 4.2 No Limited Liability Constraint

It is important to understand which assumptions within this framework are necessary for proposition 2 to hold. The purpose of this subsection is to show that an environment with no limited liability constraint would leave the agents indifferent concerning the hiring processes.

**Lemma 1**: If the principal is unburdened from a limited liability constraint, then the labour policies described in subsection 4.1 would have no impact on the discrimination faced by the marginalised workers and their expected utility.

If the principal can demand an upfront payment from the marginalised worker and another one from the favoured agent, the principal would absorb all of the total surplus and bind the agents to their participation constraints. More formally, an environment with no limited liability constraint is a sub-case in this paper's framework where $\alpha = 1$. Since the agents expect zero utility from either hiring process, regardless of their affiliation with a favoured or marginalised group, they no longer value one hiring process over another. Therefore, the channel through which labour policies could amplify the discrimination faced by marginalised workers is muted, and result 4.2-i would no longer hold. Furthermore, if the probability of an ambiguous signal being generated by either process varies, the principal would simply alter the upfront payments, thereby leaving the agents unaffected by these variations.

Lemma 4.1 is interesting because it suggests that labour regulations, which increase the workers' share of the total surplus, will introduce preferences for different hiring process. These regulations complement each other in often unforeseen ways and can harm some of the workers they aim to protect.

## 5 Conclusion

In conclusion, I argue that the ultimate determinants of the optimal hiring process are the accuracy of the signals being generated and their costs. I also expose the channels through which the returns to information can affect the optimal hiring process. More importantly, this paper provides some theoretical arguments as to how labour regulations can actually harm the same workers they aim to protect, especially those originating from marginalised groups. Specifically, I showed that a policy establishing a minimum wage for interns can push employers towards using a hiring process that marginalised workers dislike. I also showed that a policy that aims to protect workers from malicious past employers can actually harm marginalised workers, by exposing them to more discriminatory practices.

Allowing more complexity into the discriminatory signalling model, such as allowing the signals to differ for agents of different types, or allowing an ambiguous signal for one agent and an unambiguous one for the other, should help uncover some additional insights. One can think of how social mobility or poverty traps for disenfranchised communities with poorer educational outcomes compare to those with higher educational options. Some minority workers might prefer the discrimination-filled investigation process simply because they cannot afford to work for no pay (e.g. having to feed one's family). This can be seen as a setting where poverty in a disenfranchised community can slow down institutional changes that seek to minimise and eliminate discrimination. Expanding the number of hiring processes available to the principal or adding macroeconomic dynamics to the framework should help reveal additional insights on these subjects. Further work to enhance this framework should yield promising results.

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## 6 Appendix

**Proof of Proposition 1**:

Part i)

It must first be noticed that $\Pi_{inv} - \Pi_{int}$ can be rewritten as

$$= \frac{\alpha(1-\alpha)\eta^2}{\theta_H}[\frac{1}{2} - \frac{(1-q)(2\sigma-1)}{4}] + \frac{\alpha(1-\alpha)\eta^2}{\theta_L}[\frac{1}{2} + \frac{(1-q)(2\sigma-1)}{4}] - E - \frac{\alpha(1-\alpha)\eta^2}{\theta_H}[\frac{1}{2} - \frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}] - \frac{\alpha(1-\alpha)\eta^2}{\theta_L}[\frac{1}{2} + \frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}] + S. \quad (22)$$

For part i), when $E = S = 0$, (22) simplifies to $V_{inv} - V_{int}$.

Part ii)

For part ii), $\Pi_{inv} - \Pi_{int} > 0$ can be rewritten as

$$\frac{(1-q)(2\sigma-1)}{4}[\frac{\alpha(1-\alpha)\eta^2(\theta_H-\theta_L)}{\theta_H\theta_L}] - \frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}[\frac{\alpha(1-\alpha)\eta^2(\theta_H-\theta_L)}{\theta_H\theta_L}] - (E-S) > 0 \quad (23)$$

$$\Leftrightarrow \sigma > \frac{1}{2} + \frac{\alpha(1-\alpha)^3\eta^4(1-p)(\theta_H^2-\theta_L^2)(\theta_H-\theta_L) + 16(E-S)L^2\theta_H^3\theta_L^3}{8(1-q)L^2\theta_L^2\theta_H^2\alpha(1-\alpha)\eta^2(\theta_H-\theta_L)}. \quad (24)$$

Part iii)

For part iii), (23) can be rewritten as

$$\frac{\alpha(1-\alpha)\eta^2\theta_H(1-q)(2\sigma-1)}{4\theta_L\theta_H} - \frac{\alpha(1-\alpha)\eta^2\theta_L(1-q)(2\sigma-1)}{4\theta_L\theta_H} - \frac{\alpha(1-\alpha)^3\eta^4(1-p)(\theta_H^3-\theta_L^2\theta_H-\theta_L\theta_H^2+\theta_L^3)}{16L^2\theta_L^3\theta_H^3}$$

$$= \frac{\alpha(1-\alpha)\eta^2(1-q)(2\sigma-1)}{4\theta_L} - \frac{\alpha(1-\alpha)\eta^2(1-q)(2\sigma-1)}{4\theta_H} - \frac{\alpha(1-\alpha)^3\eta^4(1-p)}{16L^2\theta_L^3} + \frac{\alpha(1-\alpha)^3\eta^4(1-p)}{16L^2\theta_L\theta_H^2} + \frac{\alpha(1-\alpha)^3\eta^4(1-p)}{16L^2\theta_L^2\theta_H} - \frac{\alpha(1-\alpha)^3\eta^4(1-p)}{16L^2\theta_H^3}. \quad (25)$$

The derivative of (25) with respect to $-\theta_L$ yields

$$-[-\frac{\alpha(1-\alpha)\eta^2(1-q)(2\sigma-1)}{4\theta_L^2} + \frac{3\alpha(1-\alpha)^3\eta^4(1-p)}{16L^2\theta_L^4} - \frac{\alpha(1-\alpha)^3\eta^4(1-p)}{16L^2\theta_L^2\theta_H^2} - \frac{\alpha(1-\alpha)^3\eta^4(1-p)}{8L^2\theta_L^3\theta_H}]. \quad (26)$$

The equation in (26) is positive when

$$0 < \frac{\alpha(1-\alpha)\eta^2(1-q)(2\sigma-1)}{4\theta_L^2} - \frac{3\alpha(1-\alpha)^3\eta^4(1-p)}{16L^2\theta_L^4} \quad \frac{\alpha(1-\alpha)^3\eta^4(1-p)}{16L^2\theta_L^2\theta_H^2} + \frac{\alpha(1-\alpha)^3\eta^4(1-p)}{8L^2\theta_L^3\theta_H}$$

$$\Leftrightarrow e > \frac{1}{2} + [\frac{(1-\alpha)^2\eta^2(1-p)}{4(1-q)L^2}](\frac{3\theta_H^2-\theta_L^2-2\theta_H\theta_L}{2\theta_H^2\theta_L^2}),$$

which proves the first part of the result. The derivative of (25) with respect to $\theta_H$ yields

$$\frac{\alpha(1-\alpha)\eta^2(1-q)(2e-1)}{4\theta_H^2} - \frac{\alpha(1-\alpha)^3\eta^4(1-p)}{8L^2\theta_L\theta_H^3} - \frac{\alpha(1-\alpha)^3\eta^4(1-p)}{16L^2\theta_L^2\theta_H^2} + \frac{3\alpha(1-\alpha)^3\eta^4(1-p)}{16L^2\theta_H^4}. \quad (27)$$

The equation in (27) is positive when the inequality below holds:

$$(1-q)(2e-1) - \frac{(1-\alpha)^2\eta^2(1-p)}{2L^2}(\frac{1}{\theta_H\theta_L} + \frac{1}{2\theta_L^2} - \frac{3}{2\theta_H^2}) > 0$$

$$\Leftrightarrow e > \frac{1}{2} + [\frac{(1-\alpha)^2\eta^2(1-p)}{4(1-q)L^2}](\frac{2\theta_L\theta_H + \theta_H^2 - 3\theta_L^2}{2\theta_L^2\theta_H^2}),$$

which shows the second part of the result.

QED

**Proof of Proposition 2**:

Part i)

In an investigation process, an agent of type $\theta_L$ who is from a marginalised group has an expected utility of

$$\frac{1}{2}\{(1-q)0 + q[\frac{(1-\alpha)^2\eta^2}{2\theta_L}][ee + \frac{e(1-e)}{2} + \frac{(1-e)e}{2}]\} \\ + \frac{1}{2}\{(1-q)0 + q[\frac{(1-\alpha)^2\eta^2}{2\theta_L}][\frac{ee}{2} + e(1-e) + \frac{(1-e)^2}{2}]\} \quad (28)$$

$$= \frac{(1-q)(1-\alpha)^2\eta^2}{2\theta_L}(\frac{1+2e}{4}). \quad (29)$$

The first line of (28) represents what would happen if the other agent was of type $\theta_H$ (which the agent believes would happen with probability $\frac{1}{2}$) and the second represents what would happen if the agent is of type $\theta_L$. Within each set of swirly brackets, the second set of brackets represents the probability of being hired through the investigation process given the other agent's type. The first set of brackets represents the expected payoffs in the event of an ambiguous signal and an unambiguous signal, respectively.

A reminder is in order that the principal's bias is assumed to be of any consequence only in the event of an ambiguous signal being received by the principal. It is therefore irrelevant following a clear unambiguous signal about the agents' type. Subsequently, if the principal receives an unambiguous signal revealing that both agents are of type $\theta_L$, then he simply flips a coin to determine the winner, which amounts to each agent having a probability of winning of $\frac{1}{2}$, to which the expression in the brackets in the second part of (28) simplifies.

Similarly, a marginalised worker of type L expects a payoff in the investigation process of

$$\frac{1}{2}\{(q)0 + (1-q)[\frac{(1-\alpha)^2\eta^2}{2\theta_H}][e(1-e) + (1+e)^2]\} \\ + \frac{1}{2}\{(q)0 + (1-q)[\frac{(1-q)^2\eta^2}{2\theta_H}][\frac{e^2}{2} + \frac{1}{2}(1-e)^2 + e(1-e)]\}$$

$$= \frac{(1-q)(1-\alpha)^2\eta^2(3-2e)}{8\theta_H}. \quad (30)$$

Therefore, a marginalised worker who has yet to learn his type has an expected utility in the investigation process of

$$\frac{1}{2}[\frac{(1-q)(1-\alpha)^2\eta^2(3-2e)}{8\theta_H}] + \frac{1}{2}\frac{(1-q)(1-\alpha)^2\eta^2(1+2e)}{8\theta_L}$$

$$= \frac{(1-q)(1-\alpha)^2\eta^2[\theta_L(3-2e)+\theta_L(1+2e)]}{16\theta_H\theta_L}. \tag{31}$$

In an internship process, an agent of type $\theta_L$ who is from a marginalised group has an expected utility of

$$(1-p)[\frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2} + \frac{1}{2}]\frac{(1-\alpha)^2\eta^2}{2\theta_L} - \frac{\theta_L}{2}[\frac{(1-\alpha)^2\eta^2(1-p)}{4L\theta_L^2}]^2 \tag{32}$$

$$= \frac{(1-\alpha)^2\eta^2(1-p)}{4\theta_L} - \frac{(1-\alpha)^4\eta^4(1-p)^2}{32L^2\theta_L\theta_H^2}. \tag{33}$$

Similarly, a marginalised worker of type H has an expected utility of

$$\frac{(1-\alpha)^2\eta^2(1-p)}{4\theta_H} - \frac{(1-\alpha)^4\eta^4(1-p)^2}{32L^2\theta_L^2\theta_H}. \tag{34}$$

Therefore, a marginalised worker who has yet to learn his type has an expected utility in an internship process of

$$\frac{1}{2}[\frac{(1-\alpha)^2\eta^2(1-p)}{4\theta_H}] - \frac{1}{2}[\frac{(1-\alpha)^4\eta^4(1-p)^2}{32L^2\theta_L^2\theta_H}] + \frac{1}{2}[\frac{(1-\alpha)^2\eta^2(1-p)}{4\theta_L}] - \frac{1}{2}[\frac{(1-\alpha)^4\eta^4(1-p)^2}{32L^2\theta_L\theta_H^2}]$$

$$= \frac{(1-\alpha)^2\eta^2(1-p)(\theta_L+\theta_H)}{8\theta_L\theta_H} - \frac{(1-\alpha)^4\eta^4(1-p)^2(\theta_H+\theta_L)}{64L^2\theta_L^2\theta_H^2}. \tag{35}$$

By comparing both utilities, it can be seen that the marginalised worker prefers the internship process if and only if (35) > (31) holds, which is equivalent to

$$\frac{(1-p)(\theta_L+\theta_H)[8L^2\theta_L\theta_H-(1-\alpha)^2\eta^2(1-p)]}{4L^2\theta_L\theta_H[\theta_L(3-2\sigma)+\theta_H(1+2\sigma)]} \geq (1-q), \tag{36}$$

which is one of the conditions of proposition 4.2-i. It should also be noted that if (36) holds, then establishing a minimum wage for interns would simply reinforce a marginalised worker of type L's preference for the internship process.

Furthermore, it should also be noted that $\Pi_{int} > \Pi_{inv}$ when $w = 0$ holding is the equivalent of

$$\frac{\alpha(1-\alpha)\eta^2}{\theta_H}[-\frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}] + \frac{\alpha(1-\alpha)\eta^2}{\theta_L}[\frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2\theta_L^2)}{16L^2\theta_L^2\theta_H^2}] - S > \frac{\alpha(1-\alpha)\eta^2}{\theta_L}[\frac{(1-q)(2\sigma-1)}{4}] - \frac{\alpha(1-\alpha)\eta^2}{\theta_H}[\frac{(1-q)(2\sigma-1)}{4}] - E$$

holding. For the principal to find it optimal to switch to the investigation process, the minimum wage established by the government would have to be high enough that

$$w > w' \equiv E - S + \frac{\alpha(1-\alpha)\eta^2}{\theta_H}[\frac{(1-q)(2\sigma-1)}{4} - \frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}] - \frac{\alpha(1-\alpha)\eta^2}{\theta_L}[\frac{(1-q)(2\sigma-1)}{4} + \frac{(1-\alpha)^2\eta^2(1-p)(\theta_H^2-\theta_L^2)}{16L^2\theta_L^2\theta_H^2}] \quad (37)$$

would hold.

Part ii)

Differentiating (35) with respect to $p$ results in

$$\frac{(1-\alpha)^4\eta^4(1-p)(\theta_H+\theta_L)}{32L^2\theta_L^2\theta_H^2} - \frac{(1-\alpha)^2\eta^2(\theta_L+\theta_H)}{8\theta_L\theta_H},$$

which is positive if and only if

$$(1-p) > \frac{4L^2\theta_L\theta_H}{(1-\alpha)^2\eta^2},$$

which proves result 2-ii. It should be noted that the inequality $(1-p) > \frac{4L^2\theta_L\theta_H}{(1-\alpha)^2\eta^2}$ does not preclude the internship process being optimal. Since the inequality

$$\frac{2\sigma-1}{2} > \frac{\alpha(1-\alpha)^3\eta^4(1-p)(\theta_H^2-\theta_L^2)(\theta_H-\theta_L) + 16(E-S)L^2\theta_H^3\theta_L^3}{8(1-q)L^2\theta_H^2\theta_L^2\alpha(1-\alpha)\eta^2(\theta_H-\theta_L)}$$

$$\Leftrightarrow \frac{8L^2\theta_L^2\theta_H^2[(1-q)\alpha(1-\alpha)\eta^2(\theta_H-\theta_L)(2\sigma-1) - 2(E-S)\theta_H\theta_L]}{2\alpha(1-\alpha)^3\eta^4(\theta_H^2-\theta_L^2)(\theta_H-\theta_L)} > (1-p)$$

guarantees that the investigation process is optimal, it can be seen that

$$\frac{8L^2\theta_L^2\theta_H^2[(1-q)\alpha(1-\alpha)\eta^2(\theta_H-\theta_L)(2\sigma-1) - 2(E-S)\theta_H\theta_L]}{2\alpha(1-\alpha)^3\eta^4(\theta_H^2-\theta_L^2)(\theta_H-\theta_L)} > \frac{4L^2\theta_L\theta_H}{(1-\alpha)^2\eta^2}$$

$$\Leftrightarrow \theta_L\theta_H[(1-q)\alpha(1-\alpha)\eta^2(\theta_H-\theta_L)(2\sigma-1)-2(E-S)\theta_H\theta_L] > \alpha(1-\alpha)\eta^2(\theta_H^2-\theta_L^2)(\theta_H-\theta_L)$$

does not necessarily hold, meaning that the inequality $(1-p) > \frac{4L^2\theta_L\theta_H}{(1-\alpha)^2\eta^2}$ does not preclude the internship process being optimal.

Part iii)

As for result 2-iii, it follows directly from equation (31).

QED