Conformity in search markets*

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Abstract

We study how private information is used in a search market with non-transferable utility. We show that competitive pressure can turn privately informed agents into "yes men" who, against their own better judgement, mimic behavior that prior information suggests is more valuable. This is more likely to happen when prior, public information is strong relative to private information. The result is not enough frictional unemployment and search, and too much employment in activities favored by prior information. Moreover, the "yes-man" incentive grows stronger when private information is more persistent: we are more likely to lie about what we are than about what we know.

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1 Introduction

Exchange is difficult. It takes both time and effort to find an appropriate trading partner. And even when the possibility of exchange arises, institutional, informational, or cultural restrictions may make it difficult to fully understand payoffs and write optimal contracts. Moreover, the parties to an exchange often have private information about the way in which they stand to benefit from a transaction. We study how valuable private information is — or is not — used to increase the value of a trade in the face of search frictions and imperfect contracting. We find that agents with valuable private information that contradicts preconceived notions may choose not to use it. Instead, behavior coincides too much with what public information suggests is optimal. This kind of conformist behavior occurs when privately informed agents come under a lot of competitive pressure, when prior public opinions are strong and private information is weak, and when the value of a trading partner in hand relative to one that can be found through search is neither too high nor too low. The inefficiency amounts not only to relationships that are pursued being less valuable, but also to not enough search being undertaken. This suggests that the outcome may be improved upon by either restricting entry by informed agents into the market or by making search more attractive, for example through targeted unemployment compensation. Finally, we find that the incentive to lie in order to keep a trading partner grows stronger with the persistence of private information. The reason for this is that when information is more persistent, it is less likely that continued search yields a match that is better than the current one. Hence, we are more likely to lie about what we are than about what we know.

An example of a setting that we have in mind would be a worker searching for a job in an environment in which job descriptions and wages are given and nonnegotiable. If the worker should secure an interview, she has to assess how well her personal abilities and preferences fit the job, and decide whether or not to reveal her conclusion to the potential employer. Someone who considers herself a good fit for the job would, of course, have no problem revealing this. But if the worker feels that she is not quite what the employer is looking for, then she finds herself in more of a quandary: should she lie simply to get the job, or should she try to find something better? Our results, along with common sense, suggest that the worker would tend to lie if the employer were to reject her if she revealed the truth and if when that happens, finding another job opportunity looks difficult. At the market level, this may result in too many bad matches between workers and jobs and not enough frictional unemployment.

There are two basic building blocks to our theory. The first is a search environment, which provides us with a means of describing face-to-face transactions within the context of a larger market.[1] While many search models incorporate bargaining over agreement terms between matched market participants, we instead adopt the non-transferable utility framework studied by Burdett and Wright (1998) in which the amount earned by each party in the arrangement is non-negotiable.[2] We focus on this case because substantial shortcomings of contractual agreements appear to be a prominent feature of the real world. What matters for our analysis is that some of the utility of the informed party is non-transferable. This seems likely to be the case because the informed party must use her information in the relationship and therefore become actively involved in it. So part of what the informed party takes away from the relationship is her direct experience of it, which tends to be private and non-transferable.[3] Hence, we heartily agree with Burdett and Wright (1998), who motivate their use of a fixed division of payoffs by noting that virtually every contractual relationship has some non-transferable payoff, and that once one

[1]For comprehensive descriptions of search models, see, for example, Pissarides (2000) and Rogerson, Shimer, and Wright (2005).

[2]Hiroshi (2003) and Burdett, Imai, and Wright (2004) provide other examples of search models with non-transferable utility. Also, notice that we do not address the issue of how a heterogeneous population form matches with each other considered by, for example, Burdett and Coles (1997) and Legros and Newman (2007).

[3]Here we take the perspective of an extensive literature in corporate governance, exemplified by Aghion and Bolton (1992), that draws a sharp distinction in terms of the transferability of their payoffs between active and non-active parties in an economic relationship.

is acclimated to this fact, it is natural to think about the simplifying polar case in which payoffs in general are non-transferable.[4]

The second component of our story is that agents may have an incentive to conform to popular opinions. Our work therefore fits into a growing literature that investigates the effect that different economic environments and incentive mechanisms have on the management of private information. Brandenburger and Polak (1996) analyze a situation where an agent who makes a decision based on private information cares about the assessment of that decision by someone who is less well-informed. They find that such a concern for the opinion of others generically gives an incentive to misrepresent information in a way that conforms with the prior opinion of the uninformed. In short, social pressure creates "yes-men." This impulse to conform to the conventional wisdom is mitigated — but not eliminated — by a concern for real outcomes. Prendergast (1993), Gentzkow and Shapiro (2006), and Cummins and Nyman (2005) all investigate how different incentive mechanisms — explicit incentive contracts, reputation concerns, and competitive pressure, respectively — can have the unintended side-effect of distorting the use of private information and turn the informed into "yes-men." Our work expands on this literature by examining these issues in the setting of a search market. And because our model is explicitly dynamic, we are also able to contribute some insight into the role that intertemporal trade-offs and the persistence of information play in "yes-man" problems.

After presenting the model in the next section, we start our analysis by establishing what the efficient outcome looks like. With that as a benchmark, we then turn to the question of which outcome will obtain when decision-making is decentralized, but all information is public. In Section 4, we analyze the main question of interest, namely what the decentralized equilibrium looks like when informed agents' signals are private information. We also consider how the persistence of these signals

[4] The marriage market provides another prominent example of a setting in which not all gains between parties are contractible, as does the general partnership formation problem studied in Farrell and Scotchmer (1988).

over time affects the incentive for the agents to conform to prior opinions. A short discussion of assumptions and results closes out the paper.

2 Model Setup

Principals, who own an uncertain investment project, and agents, equipped with the skills to manage the project in the form of better information about the uncertainty, can make mutually beneficial trades. This is done in a search market where the two types of traders meet sequentially in discrete time. In each time period, matches between unemployed principals and agents are created. Those that are not matched remain unemployed throughout the period and go through the matching process again in the subsequent period. Once matched, the agent receives information about the project and, based on that information, either dissolves the match or presents a plan for how to manage the project. If a plan is presented, the principal can either accept the agent's plan or dissolve the match by rejecting it. If the match is dissolved, both parties go back to the market to search for a new partner in the subsequent period. If the agent presents a plan that is accepted by the principal, then the project is undertaken in the subsequent period when it may or may not be completed. If it is completed, the two parties share the profits equally, but cannot find a new match in the same period. If it is not, the parties run the project again in the subsequent period and continue to do so until it is completed.

2.1 Investment Projects

The investment project owned by a principal can be managed in one of two ways: as a blue project or as a green project. The decision about how to run the project is taken by the agent. It is denoted by $i \in \{b, g\}$, and dependency on it is indicated by a subscript. The only decision that the principal makes is whether to reject or accept the agent's plan for the project. If the principal rejects the agent's plan for the project, then both she and the agent continue their search for a trading partner. If the principal accepts the plan, then the project is undertaken. Its duration is unknown and the probability that it is completed in the current period is equal to λ.

The true state of the project is uncertain: it can be either Blue or Green. This investment uncertainty, which is independent across projects, is denoted by $I \in \{B, G\}$. The project is more profitable if the agent's decision matches the state. To simplify the analysis, we make the high and low payoff the same for both decisions and normalize the profit from unsuccessful and successful investment to zero and two, respectively. This payoff is split evenly between the principal and the agent, so if the project is successful, then each of them receives a payoff of one and if the project fails, then each of them receives a payoff of zero. This makes the individual expected value from a completed project equal to the probability that it matches the state. The payoff to the principal, $V_i(I)$, and to the agent, $v_i(I)$, if the agent chooses plan i and the state of the world is I looks as follows:

$$V_i(I) = v_i(I) = \begin{cases} 1 & \text{if } (g, G) \text{ or } (b, B) \\ 0 & \text{if } (g, B) \text{ or } (b, G) \end{cases}$$

Everyone has access to public information in the form of a prior distribution on the state space. This prior belief favors, without loss of generality, the Green state: $\mu = \Pr(I = G) \geq \frac{1}{2}$.

The agents are experts at managing the investment projects in the sense that they have additional, private information in the form of a noisy signal, denoted by $s \in \{\beta, \gamma\}$. The agent's information is unobservable to the principal. Of course, β and γ indicate that the state is likely to be B and G, respectively. The accuracy of both signal realizations is the same and is denoted by $\sigma = \Pr(\gamma|G) = \Pr(\beta|B)$. The agent's information is match-specific, so the signal realizations are conditionally independent both across agents and across time for the same agent. Finally, to make it valuable and give the agents a *raison d'être*, we assume that their signals are more accurate than the public information, i.e., that $\sigma > \mu$.

2.2 Matching and Objectives

The total numbers of agents and principals are denoted by n_a and n_p, respectively. They can be either employed or unemployed. The number of unemployed agents and principals are denoted by u_a and u_p, respectively. The number of agents and principals employed in a project of type i are denoted by $e_{i,a}$ and $e_{i,p}$, respectively. Because matching is one-to-one, the number of agents and principals that are employed in projects of type i must always be the same, and we denote their number by $e_i = e_{i,a} = e_{i,p}$. In each period, agents and principals meet and create matches according to a matching function, which we assume is given by the minimum operator: $m(u_a, u_p) = \phi \min[u_a, u_p]$. Hence, the number of matches is constrained by the short side of the market, and the efficiency of this process is parameterized by $\phi > 0$, the probability that one principal and one agent can generate a match. The matching process translates into matching probabilities for agents and principals, denoted by z and q, respectively: $z = \frac{\phi \min[u_a, u_p]}{u_a}$ and $q = \frac{\phi \min[u_a, u_p]}{u_p}$. Notice that since the number of agents and principals that are employed is the same, any population surplus ends up being unemployed, i.e., $n_a - n_p = u_a - u_p$. Therefore, if $n_a > n_p$, then $u_a > u_p$ so that $q = \phi$ and $z = \phi\left(\frac{u_p}{u_a}\right) < \phi$. Similarly, if $n_a < n_p$, then $u_a < u_p$ so that $z = \phi$ and $q = \phi\left(\frac{u_a}{u_p}\right) < \phi$.

Everyone is perfectly rational, risk-neutral, and discounts the future at a rate $r > 0$. Principals and agents alike therefore choose their actions with the objective of maximizing the expected present discounted value of their own payoff, given the information they have access to.

3 The Socially Optimal Outcome

We start out by determining what the socially optimal outcome looks like. This will serve as our efficiency benchmark when we analyze the equilibrium when decision-making is decentralized. So, in this section, decisions will be made by a social planner. For each match, the planner must decide whether to run the project as a green one, as a blue one, or to dissolve the match and let the principal and the agent search for a new match. Moreover, when making this decision, we assume that the social planner has access to the agent's private information, i.e., we are considering a completely unconstrained social planner's problem.

The objective for the social planner is to maximize the expected present discounted value of total payoffs. Since the agent's private information is more accurate than the public information, $\Pr(G|\gamma) = \frac{\mu\sigma}{\mu\sigma+(1-\mu)(1-\sigma)} > \frac{1}{2}$ and $\Pr(B|\beta) = \frac{(1-\mu)\sigma}{\mu(1-\sigma)+(1-\mu)\sigma} > \frac{1}{2}$. This means that to maximize its expected payoff, if a project is to be run, it should be run in accordance with the agent's signal. Hence, from society's point of view, no project should be run as a blue (green) project if the agent has a γ (β) signal. Furthermore, since the only reason to dissolve a match is to look for one with a better project, green projects are always pursued because the skewed prior make them weakly superior to blue ones: $\Pr(G|\gamma) \geq \Pr(B|\beta)$.[5] Therefore, the only decision remaining for the social planner is whether or not matches with blue projects should be dissolved. Not surprisingly, this turns out to be optimal if green projects are sufficiently superior to blue ones, if creating a new match is sufficiently easy, if the economy is sufficiently patient, and if completing a project is sufficiently difficult.

Proposition 1: If the agent's signal is γ, then it is always socially optimal to run the project. If the agent's signal is β, then it is socially optimal to run the project if the following condition is satisfied:

$$\frac{r+\lambda}{\phi} \geq \Pr(\gamma)\left[\frac{\Pr(G|\gamma) - \Pr(B|\beta)}{\Pr(B|\beta)}\right] \tag{1}$$

It is more likely that blue projects are socially optimal if the prior belief that green is a better project is weak (μ is small), if the agents' private information is accurate (σ is large), if discounting is heavy (r is large), if it is difficult to create a match (ϕ is small), and if it is easy to complete projects (λ is large).

Proof: See Appendix.

[5] This is an equality if $\mu = \frac{1}{2}$ and an inequality if $\mu > \frac{1}{2}$.

There are two differences between a blue project in hand and a prospective project that can be found through search. The first is that the expected profitability differs: compared to the determined profitability of the blue project, a new project holds the promise of possibly being a more profitable green project. This is captured by the right-hand side of inequality (1). The second difference is that while the blue project is already secured, the future project must be obtained through search, which both takes time and is uncertain. This bird-in-the-hand advantage for a current project is measured by the left-hand side of inequality (1), $\frac{r+\lambda}{\phi}$. The numerator represents the two advantages of running a project now rather than later. First, because of the time-value of resources, it is better to run a project one period sooner. This is measured by the discount rate, r. Second, starting the project sooner gives a better chance of completing it. This benefit is measured by the probability of completing a project, λ. The denominator represents the advantage of continued search: a new and, on average better, project may be found. This is captured by the matching probability, ϕ.

Rewriting inequality (1) in the following way makes this economic intuition quite clear: $(r+\lambda)\Pr(B|\beta) \geq \phi\Pr(\gamma)\left[\Pr(G|\gamma) - \Pr(B|\beta)\right]$. The left-hand side represents the expected value of keeping the project and running it as a blue one: the probability of completing it, λ, plus the added benefit from not having to wait another period, all multiplied by the expected payoff from a completed project, $\Pr(B|\beta)$. The right-hand side represents the expected payoff from dissolving the match and letting the parties search for a new one: the probability of getting the match, ϕ, multiplied by the probability of getting the better information, γ, and the improvement in expected payoff that this would give, $\Pr(G|\gamma) - \Pr(B|\beta)$.

4 Decentralized Decision-Making with Symmetric Information

We now turn to the analysis of the model under decentralized decision-making, i.e., when agents decide whether to run a project as blue, as green, or instead search for a new principal, and principals decide whether to accept the agent's plan for the project or reject it and instead search for a new agent. We look at pure-strategy sequential equilibria.[6]

In this section, we assume that both the principal and the agent have access to the agent's signal. If this is the case, then a principal's steady-state payoff if she starts the current period with a green project looks as follows:

$$V_g = \lambda \left[\Pr(G|\gamma) + \left(\frac{1}{1+r} \right) V_u \right] + (1-\lambda) \left(\frac{1}{1+r} \right) V_g$$

The first term captures that the project may be completed in this period, payoffs received and the next period starting with the principal searching for a new agent, the value of which is denoted V_u. The second term captures that the project may not be completed in this period, in which case the principal remains employed in a green project at the beginning of the subsequent period. Solving this expression for V_g gives

$$V_g = \left(\frac{\lambda}{r+\lambda} \right) \left[(1+r) \Pr(G|\gamma) + V_u \right] \tag{2}$$

The corresponding expression for the principal's value of a blue project is equal to

$$V_b = \left(\frac{\lambda}{r+\lambda} \right) \left[(1+r) \Pr(B|\beta) + V_u \right] \tag{3}$$

The third possibility is that the principal is unemployed at the beginning of a period. The steady-state value of this state is equal to

$$V_u = q \left\{ \Pr(\beta) \left(\frac{1}{1+r} \right) V_b + \Pr(\gamma) \left(\frac{1}{1+r} \right) V_g \right\} + (1-q) \left(\frac{1}{1+r} \right) V_u \tag{4}$$

The outcome of the principal's search in the current period will either be that she is matched or not. If she is, then it will be either with a γ- or a β-agent. This is represented by the first term. If she is not matched, then she leaves the current period unemployed. This is represented by the second term. Substituting for V_g

[6] In some situations there is also a mixed-strategy equilibrium. Such an equilibrium constitutes an attractive focal point for equilibrium selection because it is more efficient than a pure strategy equilibrium. This advantage notwithstanding, we leave it aside because of its analytical complexity.

and V_b gives us the following expression for the value of unemployment and search for the principal:

$$V_u = \frac{q\lambda(1+r)\left[\Pr(B|\beta)\Pr(\beta) + \Pr(G|\gamma)\Pr(\gamma)\right]}{r\left[r+\lambda+q\right]} \tag{5}$$

The principal's net benefit of accepting the blue project rather than continue to search can be found using equation (3):

$$V_b - V_u = \left(\frac{\lambda}{r+\lambda}\right)\left[(1+r)\Pr(B|\beta) + V_u\right] - V_u = \frac{\lambda(1+r)\Pr(B|\beta) - rV_u}{r+\lambda}$$

Substituting equation (5) into this expression gives us

$$V_b - V_u = \frac{\lambda(1+r)\left\{\Pr(B|\beta)\left[r+\lambda+q\Pr(\gamma)\right] - q\Pr(G|\gamma)\Pr(\gamma)\right\}}{(r+\lambda)\left[r+\lambda+q\right]}$$

The principal accepts the blue project if this net benefit is positive, i.e., if the bracketed expression is positive:

$$\Pr(B|\beta)\left[r+\lambda+q\Pr(\gamma)\right] - q\Pr(G|\gamma)\Pr(\gamma) \geq 0 \Leftrightarrow$$
$$\Leftrightarrow r+\lambda \geq q\Pr(\gamma)\left[\frac{\Pr(G|\gamma) - \Pr(B|\beta)}{\Pr(B|\beta)}\right]$$

The derivation of the condition for the β-agent to run a blue project rather than dissolving the match and search for a new partner in the next period is analogous, except that the matching probability is that of the agent rather than that of the principal. Therefore, the condition for the agent to stay with a blue project looks as follows:

$$r+\lambda \geq z\Pr(\gamma)\left[\frac{\Pr(G|\gamma) - \Pr(B|\beta)}{\Pr(B|\beta)}\right]$$

Blue projects are undertaken if neither principal nor agent prefers to search for a new match, i.e., if

$$r+\lambda \geq \max\{q,z\}\Pr(\gamma)\left[\frac{\Pr(G|\gamma) - \Pr(B|\beta)}{\Pr(B|\beta)}\right]$$

What do we know about $\max\{q,z\}$? Recall that $q = \phi\left[\frac{\min\{u_p,u_a\}}{u_p}\right]$ and $z = \phi\left[\frac{\min\{u_p,u_a\}}{u_a}\right]$. Therefore, it must be the case that $\max\{q,z\} = \phi\max\left\{\frac{\min\{u_p,u_a\}}{u_p}, \frac{\min\{u_p,u_a\}}{u_p}\right\} = \phi$.

This analysis is summarized in Proposition 2.

Proposition 2: If the agents' signals are public information, then green projects are always undertaken while blue ones are undertaken only if the following condition is satisfied:

$$\frac{r+\lambda}{\phi} \geq \Pr(\gamma)\left[\frac{\Pr(G|\gamma) - \Pr(B|\beta)}{\Pr(B|\beta)}\right] \tag{6}$$

This is identical to the analogous condition in Proposition 1. Therefore, if the signals are public information, then the undertaking of projects is socially optimal and the comparative statics properties are the ones described in Proposition 1.

Inequality (6) captures the same basic intuition as the analogous expression in Proposition 1: the bird-in-the-hand advantage of a blue project in this period must outweigh the profitability advantage of a more promising green project. Here, however, the prospect of searching for a new project is evaluated by the principal and the agent, rather than by a social planner. But in the end, this turns out not to matter because principals and agents together undertake blue projects in the socially optimal way. The reason why this might not have been the case is that for individuals, the difficulty of finding a new trading partner may impose an individual cost of looking for a more promising project that is not a social cost. Suppose for concreteness that there are more agents than principals.[7] Then if the blue project in hand is abandoned, the probability of finding a new match in the subsequent period is ϕ for the principal, but only $\phi\left(\frac{u_p}{u_a}\right) < \phi$ for the agent. Hence, the prospect of creating a new match is now less promising for the individual agent than it is for society because even though the principal will get matched with the objective matching probability ϕ, it may well be to a different agent. Therefore, to the agent, continued search looks grimmer than it does to society, giving her an incentive to hang on to blue projects. However, the principal faces society's trade-off between keeping the blue project and searching for a better one. And since trade is voluntary,

[7] The argument if there is a surplus of principals is analogous.

blue projects are pursued only if they measure up not only to the agent's, but also to the principal's — and society's — expected net benefit of undertaking them.

This supremacy of the short side of the market is illustrated in Figure 1. It graphs in the space of the number of agents per principal, $\frac{n_a}{n_p}$, and the bird-in-the-hand advantage, $\frac{r+\lambda}{\phi}$, the threshold for rejecting a blue project and instead searching for a new match for the principal and the β-agent. The principal and the β-agent accept a blue project above the solid and dashed curve, respectively. Facing a lot of competition when searching makes a project in hand more valuable. Therefore, when $\frac{n_a}{n_p} < 1$ ($\frac{n_a}{n_p} > 1$), so that there is a surplus of principals (agents), the value of $\frac{r+\lambda}{\phi}$ that triggers acceptance of the blue project is lower for the principal (agent). Blue projects are undertaken only if both principals and agents accept, i.e., in the intersection of the two acceptance regions, which lies above both curves. This also coincides with the socially optimal undertaking of blue projects derived in Proposition 1.

The conclusion in Proposition 2 that decentralized decision-making leads to a socially optimal outcome if the principal has access to the agent's information is not true in general, but depends on our particular choice of matching function. However, this serves us well because a decentralized efficient benchmark in the absence of information asymmetries allows our model to bring into sharper focus the question that we are interested in, namely how agents use their private information in search markets. And this is the issue to which we now turn.

5 Decentralized Decision-Making with Asymmetric Information

We now assume that the agents' signal realizations are private information, i.e., only the agent who has received it knows whether the signal is a γ or a β. Now, an agent with a β-signal can avoid searching for a new project by proposing to run the project as green instead of blue. This occurs if principals find blue projects so unattractive that they would rather search for a green proposal instead, and if agents with a

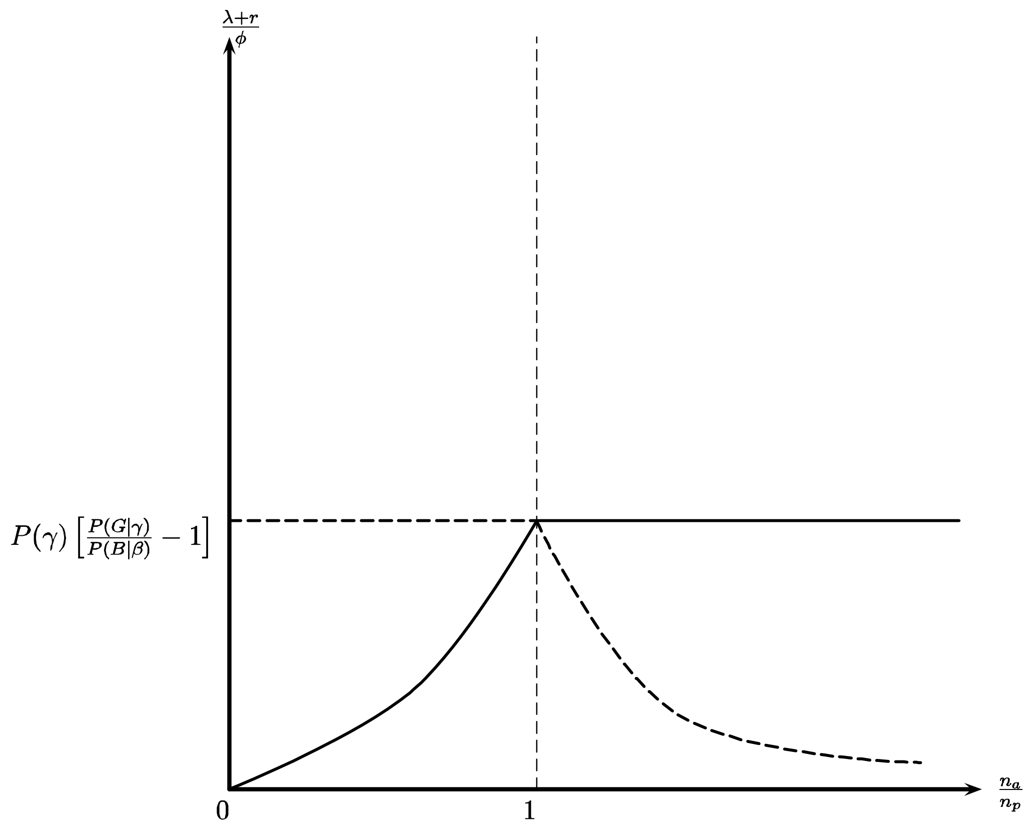

Figure 1: The undertaking of blue projects with symmetric information.

β-signal find searching for a new match so unattractive that they would rather hang on to the current one, even if it is run inefficiently. This conclusion is derived in Proposition 3.

Proposition 3: γ-agents always follow their signal. However, β-agents do not if the following condition is satisfied:

$$\left(\frac{u_p}{u_a}\right)\Pr(\gamma)\left[\frac{\Pr(G|\gamma)-\Pr(G|\beta)}{\Pr(G|\beta)}\right]<\frac{r+\lambda}{\phi}<\Pr(\gamma)\left[\frac{\Pr(G|\gamma)-\Pr(B|\beta)}{\Pr(B|\beta)}\right] \quad (7)$$

Truthful revelation is more likely if the prior belief that green is a better project is weak (μ is small), if the agents' private information is accurate (σ is large), if there are a lot of principals (n_p is large), and if there are few agents (n_a is small).

Proof: See Appendix.

The result in Proposition 3 is illustrated in Figure 2, which, once again graphs rational behavior in $(\frac{n_a}{n_p},\frac{r+\lambda}{\phi})$-space. The solid line represents the threshold for principals to accept blue projects if agents reveal their identity truthfully (the upper bound in condition (7)): above it, principals accept blue projects, below it they reject them and search for a new partner instead. The dashed line represents the threshold for β-agents to make a green proposal rather than search (the lower bound in condition (7)): below it, β-agents search and above it they would rather keep their current match even though this means that they have to lie and run the project as green in order to have it accepted. Hence, in region I, all projects are — and should be — undertaken and run in accordance with the agent's information. In region II, green projects are undertaken while β-matches are dissolved, which is socially efficient. Finally, in region III, β-matches should once again be dissolved. However, now β-agents are unwilling to reveal their identity truthfully and would rather propose to run their current projects as green than search.

It is the competitive pressure from other agents that makes β-agents so desperate to hold on to their current project that they are willing to run it inefficiently rather than look for a new one. Figure 2 makes this clear: β-agents may misrepresent

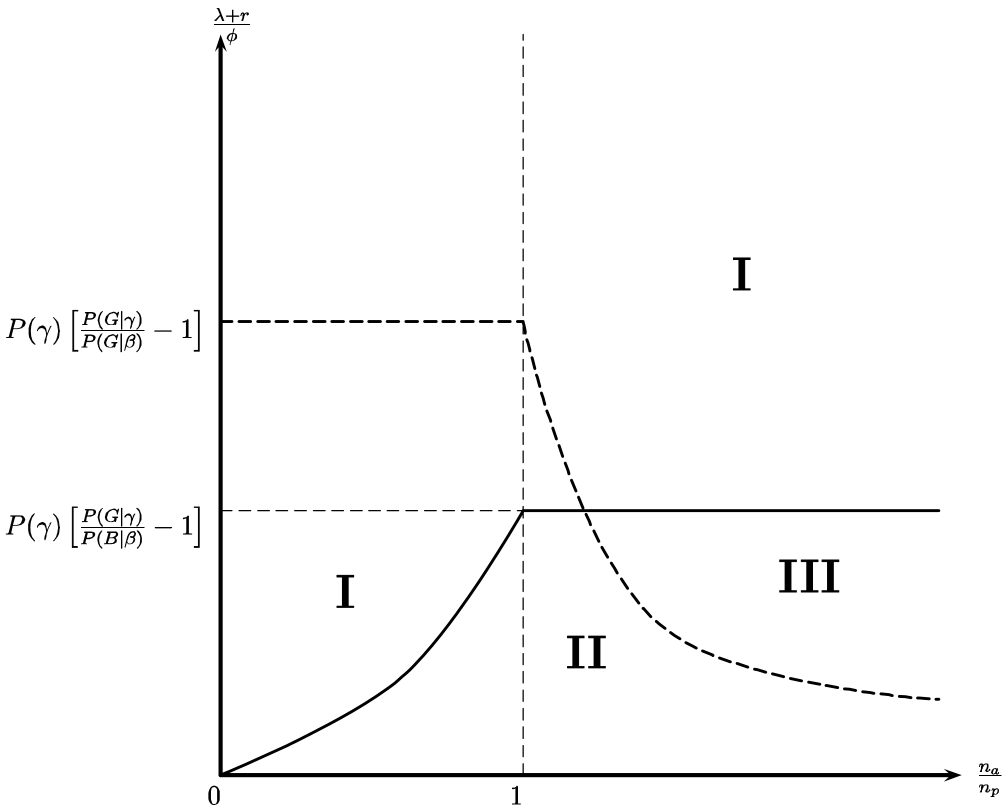

Figure 2: "Yes-man" behavior by agents with β-signals.

themselves only if there is a surplus of agents in the market, i.e., if $\frac{n_a}{n_p} > 1$. Moreover, the larger is the surplus of agents, the larger is the range of values of $\frac{r+\lambda}{\phi}$ where efficient, truthful use of information is infeasible. This result echoes that of Cummins and Nyman (2005): competitive pressure makes it costly to act with integrity and therefore breeds conformity. When a lot of agents competing for rare principals makes it sufficiently difficult to find a match, β-agents succumb to the pressure to conform and ignore their own, contrarian information.

In addition to the competitive pressure that a relative scarcity of trading partners exerts on the β-agents, their incentive to lie also depends on the accuracy of their private information, σ, relative to that of the public information, μ. In Figure 2, an increase in μ pushes the solid line up and the dashed line down, expanding the region where lying occurs: the stronger is public opinion, the more important it is to conform to it in order to secure a trading partner. When the a priori advantage of the green project is stronger, principals are more likely to reject blue projects and search for a green one instead, while for β-agents, in terms of expected profit the green project looks less bad next to the blue one. Similarly, an increase in σ pushes the solid line down and the dashed one up, shrinking the region where lying occurs: a stronger private conviction makes it more likely to be followed. With stronger private information, blue projects based on a β-signal are more profitable and therefore more attractive to the principal, while for the β-agent the cost in terms of foregone expected profit of running a green project instead of a blue one increases.

Next, we turn to the issue of precisely how β-agents and principals behave in region III of Figure 2 where β-agents fail to use their private information. This question is answered in Proposition 4.

Proposition 4: In Region III of Figure 2 where efficient project management is not possible, the unique pure-strategy equilibrium is a perfectly pooling one in which principals always reject blue projects, and both γ- and β-agents always propose to run their project as green.

This equilibrium is inefficient because there is not enough search and too many green projects, some of which have a lower profitability because the agents have a β-signal. The per-project expected social loss is equal to

$$l^* = 2\lambda \left(\frac{1+r}{r} \right) \phi\mu \left\{ \frac{\phi (1-\mu)(2\sigma - 1) - \lambda (1-\sigma)}{\{\lambda + \phi\} \{\lambda + \phi [\mu\sigma + (1-\mu)(1-\sigma)]\}} \right\} > 0 \tag{8}$$

Proof: See Appendix.

In the perfectly pooling, pure-strategy equilibrium described in Proposition 4, the β-agents have found a way around their private cost of being the one that ends up without a principal so that society can find a more promising project through their search. Instead of being forced out of their current projects by a rejecting principal, they can pretend to be what the principal is looking for, namely a γ-agent. In so doing, the β-agents waste all of their potentially valuable private information and forego the socially desirable option of searching for a new match. The transaction cost in the form of restricted contracting plays a key role in bringing about this inefficiency: the agent's surplus is non-transferable, which prevents the second-best trade of allowing the agent to keep the project by transferring some of her own surplus to the principal in exchange for the acceptance of the project.

The inefficient equilibrium has directly observable consequences in terms of the employment of principals and agents. In Region III, blue projects are inefficient, so the efficient behavior that the β-agents fail to undertake is to search for new partners. Therefore, too many green projects are undertaken and their profitability will, of course, on average be lower than if only γ-agents ran green projects. At the same time, frictional unemployment, which is a manifestation of search being undertaken, is too low. We think this is an important feature of the equilibrium because it constitutes an observable empirical implication of conformity as an attempt to avoid exposure to the competitive pressure of searching for a new trading partner.

Next, we analyze how the efficiency loss changes with the parameters of the model.

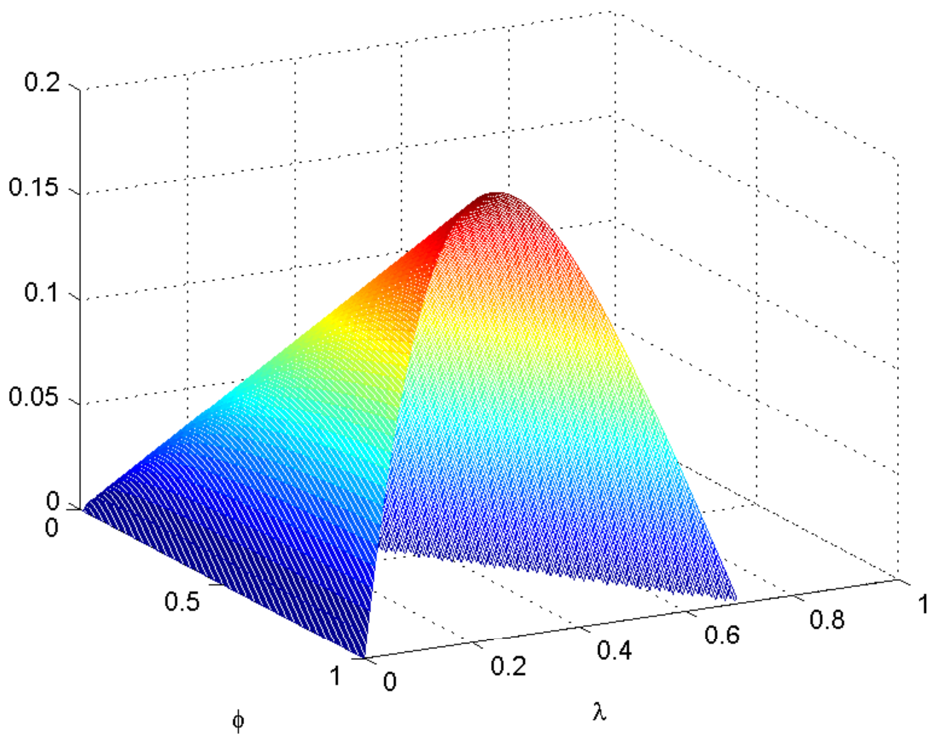

Figure 3: The efficiency loss, l^*, as a function of λ and ϕ when $r = 0.2$, $\mu = 0.65$, and $\sigma = 0.75$.

Proposition 5: l^* is strictly increasing in ϕ and σ and strictly decreasing in r, and μ. It is non-monotonic in λ: for small values of λ, the loss increases with λ, whereas for high values of λ, the opposite is true.

Proof: See Appendix.

The comparative statics properties of the efficiency loss are, for the most part, quite intuitive. An increase in ϕ and a decrease in r decreases the bird-in-the-hand advantage of the current match and therefore makes it more costly to fail to search and instead hang on to the current project. Running projects in the wrong way is less serious if green projects are heavily favored by prior information, μ, and if the information content of the β-signal, σ, that is wasted is low. The one parameter with a more complicated effect on the inefficiency is the ease with which projects are completed, λ. For small values of λ, the loss is increasing in λ, whereas when λ is large, it is decreasing in λ. This is illustrated in Figure 3. The inefficiency is non-monotonic in the probability of completing a project because λ has two competing effects on l^*. First, projects generate a payoff — and with it the inefficiency — only when they are completed. Therefore, the loss is scaled by λ, which tends to make the loss increasing in λ. Second, the probability of completing an ongoing project also affects employment and therefore the expected efficiency loss from an average project: each project now has a lower expected profit, but there are more of them. This expected loss from a completed project (the bracketed part of l^*) is decreasing in λ. A small λ shrinks this negative completed-project payoff effect and makes the overall effect positive. A large λ, by contrast, makes the change in completed project payoff important, and makes the overall effect negative.

5.1 Persistent Private Information

In the preceding analysis, an agent's private information was conditionally independent across matches. If the agent's information went unused in the current match because she was unable to come to an agreement with the principal, then she received a new signal from the identical signal process in the next match. One natural interpretation of this feature of the model is that the agent's information is about the project of the particular principal that she is currently matched with. However, another possibility is that the information that the agent has is less about a specific project and more about her own ability to run projects in different ways. In fact, in the labor market setting that we have in mind here, this seems like a reasonable and interesting possibility. We will model this as a probability, ψ, that an agent receives a new signal when she enters a new match. Hence, with probability $1-\psi$ she retains her old signal. The preceding analysis represents the special, limiting case where ψ is equal to unity, i.e., the signal is perfectly transitory.

When ψ falls and the agents' information becomes more persistent, the β-agents have a stronger incentive to lie and pretend to be their γ-type counterparts. The economic intuition behind this effect is straightforward. With more persistent information, the alternative to abandon the current match and search further becomes bleaker for the β-agent because the chance of receiving a new — and on average better — signal grows slimmer as information becomes more persistent.

Proposition 6: As the agents' private information grows more persistent, β-agents becomes more likely to conform. In the limit as signals become permanent, truthful revelation fails whenever principals reject blue projects, i.e., whenever inequality (6) is violated.

Proof: See Appendix.

The result in Proposition 6 is quite important because it says that one is less likely to lie about things the more transitory they are. To put it differently, everything else equal, one is more likely to lie about what one is than about what one knows. This is illustrated in Figure 4. The effect of an increased persistence of private information is to push the dashed line downward. This is because more persistence decreases the β-agent's individual probability of metamorphosing from a frog into a prince by getting a γ-signal in the subsequent period. However, for the principal, the probability of meeting a γ-agent in the subsequent period remains the same since this is a matter of the distribution of signals across the entire population of agents. As a result, the solid line is unaffected when information grows more persistent. In the limit when information becomes perfectly persistent, the dashed threshold becomes an L along the axes, making the region where lying occurs everything below the solid threshold: if β-agents are permanently unacceptable as trading partners, then they will disguise themselves by pretending to be sought-after γ-agents.

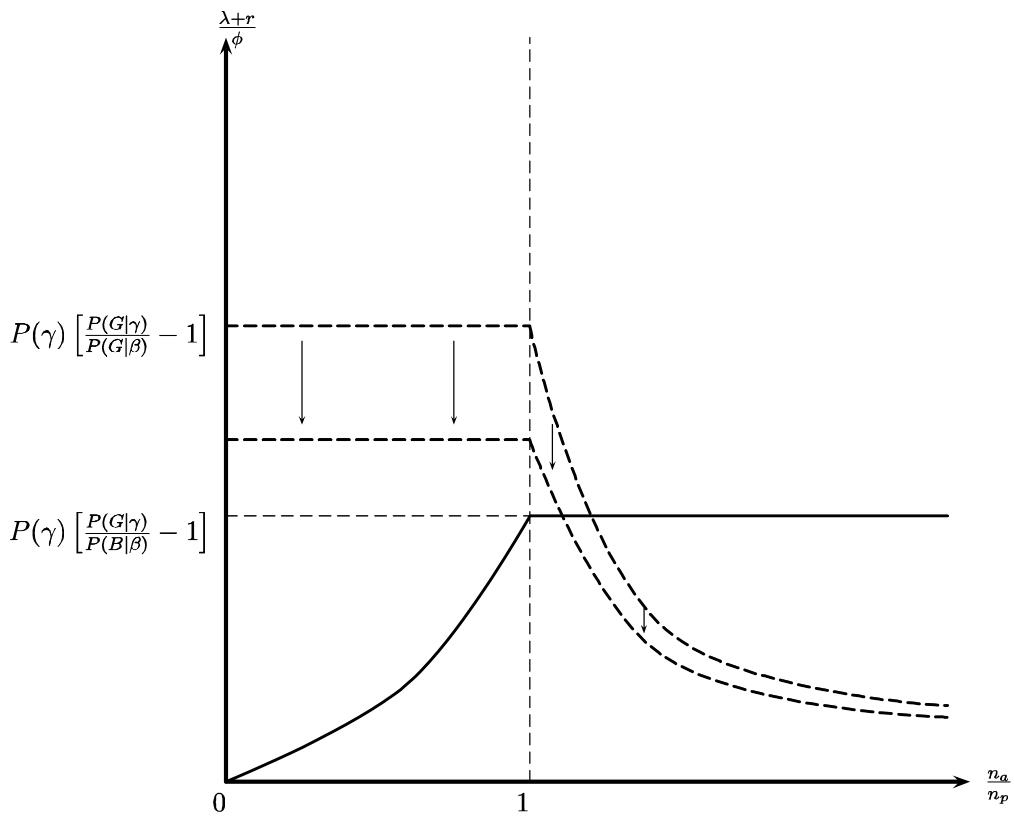

Figure 4: The effect of more persistent agent information.

6 Discussion

Our model tries to capture three features that we believe are salient in many trading environments, namely that it takes time and effort to find potential trading partners, that contracts are imperfect, and that information is asymmetric. Our results suggest that in the face of these three complications, agents have an incentive to lie and tell their trading partners what they want to hear. Such "yes-man" behavior rears its ugly head when informed agents come under competitive pressure, when the uninformed have strong opinions, and when private information is inaccurate. It leads to insufficient search and frictional unemployment, and to too many projects that are popular with the uninformed being undertaken. Moreover, in the face of conformist behavior, the projects that come to pass are on average less profitable. Finally, we find that persistent information is more costly to manage efficiently: we are more likely to lie about what we are than about what we know. In fact, if information is permanent, then it will never be revealed if it is unacceptable to potential trading partners.

When excessive conformity makes the outcome inefficient, there is room to think of how public policy might improve on the outcome. A few ways to decrease the cost of acting with integrity when you have unpopular private information come to mind. First, recall that it is competitive pressure among the informed that makes it a serious matter for them to lose their trading partner when their disappointing private information is revealed. Therefore, keeping agents out of the market would shield the informed from competitive pressure and make them less reluctant to search for new and better opportunities rather than resorting to lies in order to hang on their current one. Hence, in our simple model, either a fee or an outright ban on entry by agents could improve on the outcome by pushing us to the left in Figure 2, out of the inefficiency region. Alternatively, a subsidy to encourage more principals to enter would have the same effect.

A second way to discourage "yes-man" behavior is to increase the benefit from the efficient foregone alternative, namely continued search. One natural way to accomplish this would be to provide a monetary unemployment benefit specific to agents. This would serve as a way to compensate β-agents for search that is socially beneficial, but privately costly and therefore under-supplied in equilibrium. However, such an unemployment benefit could not be so high that it discourages the efficient pursuit of green projects by γ-agents.

The model that we developed is extremely simple. One key feature that is necessary for our conclusions is that utility is non-transferable, i.e., that the profit from each completed project is simply split down the middle. It is not the specific way that the payoff is divided that matters, but rather that this division does not depend on what the agent does. This rules out possibilities such as the β-agent bribing the principal into accepting a blue project rather than running the project as green. Hence, it is a binding limitation on the agent's access to resources that can be transferred to the principal that is critical. Our assumption here can be broken down into two distinct parts, each with a separate motivation. First, as is fairly standard in search models, we allow only the surplus from a match to be used in the agreement about what the parties should get out of the match. The standard reason for this assumption is that, due to, for example, information asymmetries, there are important credit market frictions that prevent the agent from borrowing additional resources to use in the relationship. Second, even inside the relationship, some of the agent's surplus is non-transferable. We think that in many cases of potential interest to us, this seems likely to apply because in order to make her information bear on it, the informed party must be involved in the execution of the project.[8] A non-transferable component to the agent's payoff imposes a limited-liability constraint on the contracting problem, which will prevent the necessary resource transfer to the principal if the non-transferable part of the payoff is large

[8] This distinction between active participants and outside stakeholders is standard in corporate governance theory. See, for example, Hart (1995).

enough. So even though the introduction of a transferable component to the agent's payoff would mitigate the pressure to conform by relaxing this constraint, it should not eliminate it. Hence, in summary, we do believe that the types of restrictions on contracts that we impose are in fact present in many cases where our theory might find an application. At the very least, our analysis highlights and provides insight into a problem that contracts must contend with. This is not to say that the general issue of what it takes for a contract to eliminate conformist behavior is not of the utmost interest and importance. But it is beyond the scope of this paper and must be left to future research.

The other assumptions that we make are innocuous simplifications. This is the case of the normalization of project payoffs as well as the symmetry of the agent's signal process. We also believe that our qualitative conclusions would survive the introduction of a more general matching function than the simple Leontief process that we use. The reason for this is that a robust feature of any sensible matching function should be that a larger number of agents makes it more difficult for each individual agent to find a match. This, in turn, would render search less attractive for a β-agent when she comes under competitive pressure, making her more likely to give in to the conformist temptation.

Appendix

Proof of Proposition 1: The social planner must choose the fraction of investment projects with a β-signal that are undertaken at time t, denoted by Σ_t. She does so with the objective of maximizing the total expected payoff from investment projects generated through matches between one principal and one agent. Her dynamic programming problem looks as follows:

$$W(e_{b,t}, e_{g,t}) = \max \left\{ 2\lambda \left[\Pr(B|\beta) e_{b,t} + \Pr(G|\gamma) e_{g,t} \right] + \left(\frac{1}{1+r} \right) W(e_{g,t+1}, e_{b,t+1}) \right\}$$

subject to

$$e_{b,t+1} = (1-\lambda) e_{b,t} + \Pr(\beta) \phi \{ \min[n_a, n_p] - e_{b,t} - e_{g,t} \} \Sigma_t$$

$$e_{g,t+1} = (1-\lambda) e_{g,t} + \Pr(\gamma) \phi \{ \min[n_a, n_p] - e_{b,t} - e_{g,t} \}$$

Differentiate the value function with respect to the control variable:

$$\frac{\partial W}{\partial \Sigma_t} = \left(\frac{1}{1+r} \right) \frac{\partial W}{\partial e_{b,t+1}} \frac{\partial e_{b,t+1}}{\partial \Sigma_t} = \left(\frac{1}{1+r} \right) \frac{\partial W}{\partial e_{b,t+1}} \Pr(\beta) \phi \{ \min[n_a, n_p] - e_{b,t} - e_{g,t} \}$$

This derivative is independent of Σ_t and takes on the sign of $\frac{\partial W}{\partial e_{b,t+1}}$. The fact that the value function is linear in the control variable suggests that the solution is a corner solution, i.e., that the optimal Σ_t^* is either zero or one, depending on the sign of $\frac{\partial W}{\partial e_{b,t+1}}$.

To find the envelope conditions associated with the optimal solution, differentiate the value function with respect to the two state variables, $e_{g,t}$ and $e_{b,t}$:

$$\frac{\partial W}{\partial e_{b,t}} = 2\lambda \Pr(B|\beta) + \left(\frac{1}{1+r} \right) \frac{\partial W}{\partial e_{b,t+1}} \left[1 - \lambda - \Pr(\beta) \phi \Sigma_t^* \right] - \left(\frac{1}{1+r} \right) \frac{\partial W}{\partial e_{g,t+1}} \Pr(\gamma) \phi$$

$$\frac{\partial W}{\partial e_{g,t}} = 2\lambda \Pr(G|\gamma) - \left(\frac{1}{1+r} \right) \frac{\partial W}{\partial e_{b,t+1}} \Pr(\beta) \phi \Sigma_t^* + \left(\frac{1}{1+r} \right) \frac{\partial W}{\partial e_{g,t+1}} \left[1 - \lambda - \Pr(\gamma) \phi \right]$$

We are interested in a stationary policy $e_{i,t} = e_{i,t+1} = e_i$ and $\Sigma_t^* = \Sigma_{t+1}^* = \Sigma^*$:

$$\frac{\partial W}{\partial e_b} = 2\lambda \Pr(B|\beta) + \left(\frac{1}{1+r} \right) \frac{\partial W}{\partial e_b} \left[1 - \lambda - \Pr(\beta) \phi \Sigma^* \right] - \left(\frac{1}{1+r} \right) \frac{\partial W}{\partial e_g} \Pr(\gamma) \phi$$

$$\frac{\partial W}{\partial e_g} = 2\lambda \Pr(G|\gamma) + \left(\frac{1}{1+r}\right)\frac{\partial W}{\partial e_g}\left[1-\lambda-\Pr(\gamma)\phi\right] - \left(\frac{1}{1+r}\right)\frac{\partial W}{\partial e_b}\Pr(\beta)\phi\Sigma^*$$

Solving these two equations for $\frac{\partial W}{\partial e_b}$ gives us:

$$\frac{\partial W}{\partial e_b} = 2\lambda(1+r)\left[\frac{\Pr(B|\beta)(r+\lambda) - \phi\Pr(\gamma)\left[\Pr(G|\gamma)-\Pr(B|\beta)\right]}{(\lambda+r)\left[r+\lambda+\phi\Pr(\beta)\Sigma^*+\phi\Pr(\gamma)\right]}\right]$$

Recall that the sign of this derivative determines whether or not blue projects should be undertaken: if it is positive, then $\Sigma^* = 1$, while $\Sigma^* = 0$ if it is negative. Hence, it is socially optimal to undertake blue projects if and only if

$$\Pr(B|\beta)(r+\lambda) - \phi\Pr(\gamma)\left[\Pr(G|\gamma)-\Pr(B|\beta)\right] > 0$$

$$r+\lambda \geq \phi\Pr(\gamma)\left[\frac{\Pr(G|\gamma)-\Pr(B|\beta)}{\Pr(B|\beta)}\right]$$

■

Proof of Proposition 3: When matched with a principal, a β-agent has three choices: run the project as blue, run it as green, or reject the principal's offer and continue to search. For her to lie, it must be true that this strictly dominates both the other alternatives. The only reason for a β-agent to run a project as green is if that is the only way to get the project, i.e., if the principal rejects the agent if she runs the project as blue. From Proposition 2, we know that this happens if the following condition is satisfied:

$$r+\lambda < q\Pr(\gamma)\left[\frac{\Pr(G|\gamma)-\Pr(B|\beta)}{\Pr(B|\beta)}\right] \tag{9}$$

But it must also be the case that, given that the blue project is rejected, the β-agent prefers to run the project as green rather than continue to search instead. Consider first the agent's benefit from not lying, in which case she searches for a new principal/project in the subsequent period. Her steady-state value of entering that period without a match if she does not lie looks as follows:

$$(1+r)v_u = z\left\{\Pr(\beta)v_b(\beta) + \Pr(\gamma)v_g(\gamma)\right\} + (1-z)v_u \tag{10}$$

A γ-agent's steady-state utility from running a green project is equal to

$$v_g(\gamma) = \lambda \left[\Pr(G|\gamma) + \left(\frac{1}{1+r} \right) v_u \right] + (1-\lambda) \left(\frac{1}{1+r} \right) v_g(\gamma) \Leftrightarrow$$

$$\Leftrightarrow v_g(\gamma) = \left(\frac{\lambda}{r+\lambda} \right) [(1+r) \Pr(G|\gamma) + v_u] \tag{11}$$

Since the principal rejects the agent if she proposes to run the project as a blue one, $v_b(\beta) = v_u$. Therefore, substituting equation (11) into (10) and solving for v_u gives

$$v_u = \frac{z\lambda(1+r) \Pr(G|\gamma) \Pr(\gamma)}{r[r+\lambda+z\Pr(\gamma)]} \tag{12}$$

Consider next the β-agent's benefit from lying. If she does, her steady-state utility from running the project as green looks as follows:

$$v_g(\beta) = \lambda \left[\Pr(G|\beta) + \left(\frac{1}{1+r} \right) v_u \right] + (1-\lambda) \left(\frac{1}{1+r} \right) v_g(\beta) \Leftrightarrow$$

$$\Leftrightarrow v_g(\beta) = \left(\frac{\lambda}{r+\lambda} \right) [(1+r) \Pr(G|\beta) + v_u] \tag{13}$$

The net benefit from doing so rather than continue to search is therefore equal to

$$v_g(\beta) - v_u = \left(\frac{\lambda}{r+\lambda} \right) [(1+r) \Pr(G|\beta) + v_u] - v_u = \frac{\lambda(1+r) \Pr(G|\beta) - rv_u}{r+\lambda}$$

Substituting equation (12) into this expression gives us

$$v_g(\beta) - v_u = \frac{\lambda(1+r) \{\Pr(G|\beta)[r+\lambda+z\Pr(\gamma)] - z\Pr(G|\gamma) \Pr(\gamma)\}}{(r+\lambda)[r+\lambda+z\Pr(\gamma)]}$$

The β-agent chooses to run the project as green rather than continue to search if this expression is strictly positive, i.e., if the bracketed expression is strictly positive:

$$\Pr(G|\beta)[r+\lambda+z\Pr(\gamma)] - z\Pr(G|\gamma) \Pr(\gamma) > 0 \Leftrightarrow$$

$$\Leftrightarrow r+\lambda > z\Pr(\gamma) \left[\frac{\Pr(G|\gamma) - \Pr(G|\beta)}{\Pr(G|\beta)} \right]$$

Combining this inequality with inequality (9) gives us

$$z\Pr(\gamma) \left[\frac{\Pr(G|\gamma) - \Pr(G|\beta)}{\Pr(G|\beta)} \right] < r+\lambda < q\Pr(\gamma) \left[\frac{\Pr(G|\gamma) - \Pr(B|\beta)}{\Pr(B|\beta)} \right]$$

Since the bracketed expression in the lower bound is smaller than that of the upper bound, for this condition to hold and truth-telling to fail, it must be the case that $z < q$. This, in turn, happens only if $n_p < n_a$, so that $q = \phi$ and $z = \phi\left(\frac{u_p}{u_a}\right) < \phi$. Notice that u_p (u_a) is strictly increasing in n_p (n_a) and independent of n_a (n_p). Substituting for z and q now yields condition (7).

The range of values of $\frac{r+\lambda}{\phi}$ that makes the β-agent lie is given by

$$\Pr(\gamma)\left[\frac{\Pr(G|\gamma)-\Pr(B|\beta)}{\Pr(B|\beta)}\right]-\left(\frac{u_p}{u_a}\right)\Pr(\gamma)\left[\frac{\Pr(G|\gamma)-\Pr(G|\beta)}{\Pr(G|\beta)}\right]$$

Substituting for the probabilities and simplifying reveals that this expression is equal to

$$\left(\frac{1-\sigma}{1-\mu}\right)(2\mu-1)-\left(\frac{u_p}{u_a}\right)\left(\frac{1-\mu}{1-\sigma}\right)(2\sigma-1)$$

This expression is obviously strictly increasing in n_a and strictly decreasing in n_p. Moreover, it is easy to confirm that it is strictly increasing in μ and strictly decreasing in σ. ∎

Proof of Proposition 4: If condition (7) is satisfied, then a perfectly pooling, pure-strategy equilibrium exists in which all agents always choose green and principals always accept green projects and reject blue ones. Out-of-equilibrium beliefs for the principal must be specified to complete the proposed equilibrium. To restrict such beliefs, we require that they satisfy universal divinity. Therefore, if a blue proposal is made, the must principal interpret this as a proposal that is for sure made by a β-agent. This out-of-equilibrium belief is the only one that satisfies universal divinity because the expected profit from a blue project is strictly higher given a β-signal than a γ-signal. This results in the specified equilibrium strategies being sequentially rational. Moreover, the equilibrium is unique because the only other perfectly pooling equilibrium, namely that agents always choose the blue, cannot be held together by out-of-equilibrium beliefs that satisfy universal divinity because a green project supported by a γ-signal will always be accepted by principals.

Next, turn to the social loss from this inefficient equilibrium. Denote first-best efficiency by two asterisks and the pure-strategy equilibrium by one asterisk. Inefficient use of β-signals can occur only if principals reject blue projects. Moreover, it is also necessary that there are more agents than principals, which, in turn, implies that the principals' rejection of blue projects is socially optimal. Therefore, the first-best efficient outcome is that only green projects are undertaken. We will first derive the total social welfare from this outcome. If only green projects are undertaken, the expected payoff at time t for a principal who is employed in a green project and unemployed, respectively, look as follows:

$$V_{g,t}^{**} = \lambda \left[\Pr(G|\gamma) + \left(\frac{1}{1+r} \right) V_{u,t+1}^{**} \right] + (1-\lambda) \left(\frac{1}{1+r} \right) V_{g,t+1}^{**}$$

$$V_{u,t}^{**} = \left(\frac{1}{1+r} \right) q_t \left[\Pr(\gamma) V_{g,t+1}^{**} + \Pr(\beta) V_{u,t+1}^{**} \right] + \left(\frac{1}{1+r} \right) (1-q_t) V_{u,t+1}^{**}$$

Focusing on a steady state, everything is time-invariant, which allows us to solve these equations for V_g^{**} and V_u^{**}:

$$V_g^{**} = \frac{[r + q\Pr(\gamma)] \lambda \Pr(G|\gamma)(1+r)}{r [r + \lambda + q\Pr(\gamma)]}$$

$$V_u^{**} = \frac{\lambda q \Pr(\gamma) \Pr(G|\gamma)(1+r)}{r [r + \lambda + q\Pr(\gamma)]}$$

The analogous derivation of steady state expected welfare for an agent look as follows:

$$v_g^{**} = \frac{[r + z\Pr(\gamma)] \lambda \Pr(G|\gamma)(1+r)}{r [r + \lambda + z\Pr(\gamma)]}$$

$$v_u^{**} = \frac{\lambda z \Pr(\gamma) \Pr(G|\gamma)(1+r)}{r [r + \lambda + z\Pr(\gamma)]}$$

The total welfare for the entire population of agents and principals is obtained by summing each of the above welfare expressions over the population of each type of agent and principal. Starting with the number of principals who are employed (exclusively in green projects, of course), their number is given by:

$$e_p^{**} = (1-\lambda) e_p^{**} + \Pr(\gamma) q u_p^{**} = (1-\lambda) e_p^{**} + \Pr(\gamma) q \left(n_p^{**} - e_p^{**} \right) \Leftrightarrow e_p^{**} = \frac{n_p q \Pr(\gamma)}{\lambda + q\Pr(\gamma)}$$

The number of unemployed principals is given by:

$$u_p^{**} = (1-q)\, u_p^{**} + \Pr(\beta)\, q u_p^{**} + \lambda e_p^{**} = (1-q)\, u_p^{**} + \Pr(\beta)\, q u_p^{**} + \lambda \left(n_p^{**} - u_p^{**}\right) \Leftrightarrow$$

$$\Leftrightarrow u_p^{**} = \frac{n_p \lambda}{\lambda + q\Pr(\gamma)}$$

Similarly, the number of employed and unemployed agents look as follows:

$$e_a^{**} = \frac{n_a z \Pr(\gamma)}{\lambda + z\Pr(\gamma)}$$

$$u_a^{**} = \frac{n_a \lambda}{\lambda + z\Pr(\gamma)}$$

The total welfare is the sum of the individual welfare across all individuals in the different subpopulations:

$$\begin{aligned}
W^{**} &= e_p^{**} V_g^{**} + e_a^{**} v_g^{**} + u_p^{**} V_u^{**} + u_a^{**} v_u^{**} = \\
&= \left[\frac{n_p q \Pr(\gamma)}{\lambda + q\Pr(\gamma)}\right] \left\{\frac{[r + q\Pr(\gamma)]\, \lambda \Pr(G|\gamma)(1+r)}{r\,[r + \lambda + q\Pr(\gamma)]}\right\} + \\
&+ \left[\frac{n_a z \Pr(\gamma)}{\lambda + z\Pr(\gamma)}\right] \left\{\frac{[r + z\Pr(\gamma)]\, \lambda \Pr(G|\gamma)(1+r)}{r\,[r + \lambda + z\Pr(\gamma)]}\right\} + \\
&+ \left[\frac{n_p \lambda}{\lambda + q\Pr(\gamma)}\right] \left\{\frac{\lambda q \Pr(\gamma) \Pr(G|\gamma)(1+r)}{r\,[r + \lambda + q\Pr(\gamma)]}\right\} + \\
&+ \left[\frac{n_a \lambda}{\lambda + z\Pr(\gamma)}\right] \left\{\frac{\lambda z \Pr(\gamma) \Pr(G|\gamma)(1+r)}{r\,[r + \lambda + z\Pr(\gamma)]}\right\} = \\
&= \lambda \Pr(G|\gamma) \left(\frac{1+r}{r}\right) \left\{\left[\frac{n_a z \Pr(\gamma)}{\lambda + z\Pr(\gamma)}\right] + \left[\frac{n_p q \Pr(\gamma)}{\lambda + q\Pr(\gamma)}\right]\right\} = \\
&= \lambda \Pr(\gamma) \Pr(G|\gamma) \left(\frac{1+r}{r}\right) \left\{e_a^{**} + e_p^{**}\right\}
\end{aligned}$$

Since each match is made up of one principal and one agent, $e_{a,g} = e_{p,g} = e_g$. Moreover, since $n_a > n_p$, $q = \phi$. Therefore, it follows that

$$W^{**} = 2\lambda \left(\frac{1+r}{r}\right) \Pr(G|\gamma)\, e_g^{**} = \frac{2\lambda \Pr(\gamma) \Pr(G|\gamma)(1+r)\, n_p \phi}{r\,[\phi \Pr(\gamma) + \lambda]}$$

This is the total welfare from all projects. Because $n_a > n_p$, the number of projects is proportional to n_p. Therefore, the welfare per project is equal to

$$w^{**} \equiv \frac{W^{**}}{n_p} = \frac{2\lambda \Pr(\gamma) \Pr(G|\gamma)(1+r)\, \phi}{r\,[\phi \Pr(\gamma) + \lambda]}$$

Next, turn to the expected social welfare from the pure-strategy, perfectly pooling equilibrium where all agents propose to run their projects as green, all green proposals are accepted, and all blue projects are rejected. Using the same methodology as above, the expected value to a principal of running a green project and being unemployment look as follows:

$$V_g^* = \frac{\lambda(1+r)\Pr(G|g)\{r\{r+\lambda+q\Pr(g)\}+q\lambda\Pr(g)\}}{r\{r+\lambda+q\Pr(g)\}(r+\lambda)}$$

$$V_u = \frac{q\lambda(1+r)\Pr(G|g)\Pr(g)}{r\{r+\lambda+q\Pr(g)\}}$$

The corresponding expressions for the agent are equal to:

$$v_g^* = \frac{\lambda(1+r)\Pr(G|g)\{r\{r+\lambda+z\Pr(g)\}+z\lambda\Pr(g)\}}{r\{r+\lambda+z\Pr(g)\}(r+\lambda)}$$

$$v_u^* = \frac{z\lambda(1+r)\Pr(G|g)\Pr(g)}{r\{r+\lambda+z\Pr(g)\}}$$

The number of principals in the two states is given by

$$e_{g,p}^* = \frac{n_p q\Pr(g)}{\lambda+q\Pr(g)}$$

$$u_p^* = \frac{n_p\lambda}{\lambda+q\Pr(g)}$$

For agents, these populations are equal to

$$e_{g,a}^* = \frac{n_a z\Pr(g)}{\lambda+z\Pr(g)}$$

$$u_a^* = \frac{n_a\lambda}{\lambda+z\Pr(g)}$$

Total welfare is the sum of the expected welfare across all principals and agents:

$$W^* = e_{g,p}^* V_g^* + e_{g,a}^* v_g^* + u_p^* V_u^* + u_a^* v_u^*$$

A cumbersome simplification analogous to the one for the efficient outcome above yields the following expression for total welfare:

$$W^* = 2\lambda\left(\frac{1+r}{r}\right)\Pr(G|g)\,e_g^* =$$

$$= \frac{2\lambda (1+r) n_p \phi \Pr (G|g) \Pr (g)}{r \{\lambda + \phi \Pr (g)\}}$$

The per-project welfare is equal to

$$w^* = \frac{2\lambda (1+r) \phi \Pr (G|g) \Pr (g)}{r \{\lambda + \phi \Pr (g)\}}$$

Finally, the total loss from lying is the difference between the welfare from the efficient outcome and that from the pure-strategy equilibrium:

$$L^* = W^{**} - W^* = 2\lambda \left(\frac{1+r}{r}\right) \Pr (G|\gamma) e_g^{**} - \left\{2\lambda \left(\frac{1+r}{r}\right) \Pr (G|g) e_g^*\right\}$$

Substituting for the populations and simplifying we arrive at

$$L^* = 2\lambda \left(\frac{1+r}{r}\right) n_p \phi \left\{\frac{\{\Pr (G,\gamma) \{\lambda + \phi \Pr (g)\} - \Pr (G,g) [\lambda + \phi \Pr (\gamma)]\}}{[\lambda + \phi \Pr (\gamma)] \{\lambda + \phi \Pr (g)\}}\right\}$$

Dividing by the number of principals, n_p, to get the per-project loss, and substituting for $\Pr (g) = 1$ yields

$$l^* = 2\lambda \left(\frac{1+r}{r}\right) \phi \left\{\frac{\{\Pr (G,\gamma) \{\lambda + \phi\} - \Pr (G,g) [\lambda + \phi \Pr (\gamma)]\}}{[\lambda + \phi \Pr (\gamma)] \{\lambda + \phi\}}\right\} =$$

$$= 2\lambda \left(\frac{1+r}{r}\right) \phi \left\{\frac{\lambda [\mu\sigma - \mu] + \phi \{\mu\sigma - \mu [\mu\sigma + (1-\mu)(1-\sigma)]\}}{[\lambda + \phi \Pr (\gamma)] \{\lambda + \phi\}}\right\} =$$

$$= 2\lambda \left(\frac{1+r}{r}\right) \phi\mu \left\{\frac{\phi (1-\mu)(2\sigma - 1) - \lambda (1-\sigma)}{[\lambda + \phi \Pr (\gamma)] \{\lambda + \phi\}}\right\}$$

The loss takes on the sign of the numerator of the bracketed expression, so we want to confirm that it is strictly positive.

$$\phi (1-\mu)(2\sigma - 1) - \lambda (1-\sigma) > 0$$

$$\frac{(1-\mu)(2\sigma - 1)}{(1-\sigma)} > \frac{\lambda}{\phi}$$

Notice that in Region III of the parameter space condition (7) is satisfied so that

$$\Pr (\gamma) \left[\frac{\Pr (G|\gamma) - \Pr (B|\beta)}{\Pr (B|\beta)}\right] > \frac{r + \lambda}{\phi} > \frac{\lambda}{\phi}$$

From the proof of Proposition 3, we know that

$$\Pr (\gamma) \left[\frac{\Pr (G|\gamma) - \Pr (B|\beta)}{\Pr (B|\beta)}\right] = \frac{(1-\sigma)(2\mu - 1)}{(1-\mu)}$$

Therefore, to establish that $l^* > 0$, it suffices to show that

$$\frac{(1-\mu)(2\sigma-1)}{(1-\sigma)} \geq \frac{(1-\sigma)(2\mu-1)}{(1-\mu)}$$

$$(1-\mu)^2 \sigma - (1-\mu)^2 (1-\sigma) \geq (1-\sigma)^2 \mu - (1-\sigma)^2 (1-\mu)$$

$$(1-\mu)^2 \sigma - (1-\sigma)^2 \mu - (1-\mu)(1-\sigma)(\sigma-\mu) \geq 0$$

$$(1-\mu)\sigma[(1-\mu)-(1-\sigma)] + (1-\sigma)\mu[(1-\mu)-(1-\sigma)] \geq 0$$

$$(\sigma-\mu)[\mu(1-\sigma) + (1-\mu)\sigma] \geq 0$$

This holds because the agents' private information is more accurate than the public information.

Finally, we compare the equilibrium level of unemployment to the first-best efficient one. Start with principals.

$$u_p^* - u_p^{**} =$$

$$= \frac{n_p \lambda}{\lambda + q\left[\Pr(g) + \pi_b^* \Pr(b)\right]} - \frac{n_p \lambda}{\lambda + q \Pr(\gamma)} =$$

$$= \frac{n_p \lambda}{\lambda + \phi \Pr(g)} - \frac{n_p \lambda}{\lambda + \phi \Pr(\gamma)} =$$

$$= \frac{n_p \lambda \{[\lambda + \phi \Pr(\gamma)] - [\lambda + \phi \Pr(g)]\}}{[\lambda + \phi \Pr(g)][\lambda + \phi \Pr(\gamma)]} =$$

$$= \frac{n_p \lambda \phi [\Pr(\gamma) - \Pr(g)]}{[\lambda + \phi \Pr(g)][\lambda + \phi \Pr(\gamma)]} =$$

$$= \frac{n_p \lambda \phi [\Pr(\gamma) - 1]}{[\lambda + \phi \Pr(g)][\lambda + \phi \Pr(\gamma)]} < 0$$

A comparison of the two unemployment rates for agents yields the same conclusion. ■

Proof of Proposition 5: We differentiate the loss function with respect to each of the parameters. Some rearranging and simplifying gives us the following.

$$\frac{\partial l^*}{\partial r} = -2\lambda\phi\mu r^{-2} \left\{ \frac{\phi(1-\mu)(2\sigma-1) - \lambda(1-\sigma)}{[\lambda + \phi \Pr(\gamma)]\{\lambda + \phi\}} \right\} < 0$$

$$\frac{\partial l^*}{\partial \sigma} = 2\lambda\left(\frac{1+r}{r}\right)\left(\frac{\phi}{\lambda+\phi}\right)\mu\left\{\frac{\lambda^2+\phi\left(2-\mu\right)+\phi^2\left(1-\mu\right)}{\left[\lambda+\phi\Pr\left(\gamma\right)\right]^2}\right\} > 0$$

$$\frac{\partial l^*}{\partial \mu} = -2\lambda\left(\frac{1+r}{r}\right)\left(\frac{\phi}{\lambda+\phi}\right)\left\{\frac{\mu}{\left[\lambda+\phi\Pr\left(\gamma\right)\right]^2}\right\}\left\{\left\{\phi\mu\left(2\sigma-1\right)+\lambda\left(1-\sigma\right)\right\}\left\{\lambda+\phi\Pr\left(\gamma\right)\right\}+\right.$$
$$\left.+\phi\left(2\sigma-1\right)\left\{\phi\left(1-\mu\right)\left(2\sigma-1\right)-\lambda\left(1-\sigma\right)\right\}\right\} < 0$$

To find the derivative with respect to ϕ, rewrite the loss in the following way:

$$l^* = 2\lambda\left(\frac{1+r}{r}\right)\phi\mu\left(1-\sigma\right)\left\{\frac{\left[\frac{\phi(1-\mu)(2\sigma-1)}{1-\sigma}\right]-\lambda}{\left[\lambda+\phi\Pr\left(\gamma\right)\right]\left\{\lambda+\phi\right\}}\right\}$$

Differentiate with respect to ϕ:

$$\frac{\partial l^*}{\partial \phi} = 2\lambda\left(\frac{1+r}{r}\right)\mu\left(1-\sigma\right)\lambda\phi^2\left\{\frac{\Pr\left(\gamma\right)+\left[1+\Pr\left(\gamma\right)\right]\left[\frac{(1-\mu)(2\sigma-1)}{1-\sigma}\right]}{\left(\lambda+\phi\right)^2\left[\lambda+\phi\Pr\left(\gamma\right)\right]^2}\right\}+$$
$$+2\lambda\left(\frac{1+r}{r}\right)\mu\left(1-\sigma\right)\lambda^2\left\{\frac{2\phi\left[\frac{(1-\mu)(2\sigma-1)}{1-\sigma}\right]-\lambda}{\left(\lambda+\phi\right)^2\left[\lambda+\phi\Pr\left(\gamma\right)\right]^2}\right\} > 0$$

The conclusion that l^* is strictly increasing in ϕ follows from fact that $\frac{(1-\mu)(2\sigma-1)}{1-\sigma} > \frac{\lambda}{\phi}$, which was established in the proof of Proposition 4. ■

Proof of Proposition 6: Let the probability that an agent receives a new signal when she enters a new match be denoted by ψ. With probability $1-\psi$, the agent keeps the signal from her previous match. Hence, ψ parameterizes the extent to which the agents' information is transitory: it is perfectly persistent when $\psi = 0$ and perfectly transitory when $\psi = 1$, which was the case in our analysis up to this point.

Consider first whether it is rational for the principal to accept blue projects if agent's reveal their information truthfully. We derived the net benefit for principals from accepting blue projects in Proposition 2. If the agent receives a new signal in the current match, which happens with probability ψ, then the probability of the new signals being γ and β, respectively, are the same as when information were transitory. If the agent does not receive a new signal, which happens with probability

$1-\psi$, then the probability that she has a γ or a β signal is equal to the relative frequency of these types of agents among the unemployed. But since we assume that agents follow their signals and blue projects are accepted, the frequency of γ and β signals in the unemployed population of agents is equal to the $\Pr(\gamma)$ and $\Pr(\beta)$, respectively. It therefore follows that the probability of a future match being green and blue is still equal to $\Pr(\gamma)$ and $\Pr(\beta)$, respectively. Hence, the principals net benefit of accepting blue project (the upper bound in condition (7)) remains unaltered by ψ.

Turn next to the β-agent. From the proof of Proposition 3 (equation (11)), we know that the value to a γ-agent of being employed in a green project is equal to

$$v_g(\gamma) = \left(\frac{\lambda}{r+\lambda}\right)[(1+r)\Pr(G|\gamma) + v_u]$$

Again from the proof of Proposition 2 (equation (10)) we know that the value to a β-agent of continued search when information is completely transitory looks as follows:

$$(1+r)\,v_u = z\left\{\Pr(\beta)\,v_b(\beta) + \Pr(\gamma)\,v_g(\gamma)\right\} + (1-z)\,v_u$$

In the general case where the extent to which information is transitory is parameterized by ψ, this expression becomes

$$(1+r)\,v_u = z\left\{\psi\left[\Pr(\beta)\,v_b(\beta) + \Pr(\gamma)\,v_g(\gamma)\right] + (1-\psi)\,v_b(\beta)\right\} + (1-z)\,v_u$$

Since the principal rejects blue projects, $v_b(\beta) = v_u$, making the value to a β-agent of being unemployed equal to

$$(1+r)\,v_u = z\left\{\psi\left[\Pr(\beta)\,v_u + \Pr(\gamma)\,v_g(\gamma)\right] + (1-\psi)\,v_u\right\} + (1-z)\,v_u$$

Substituting for $v_g(\gamma)$ and rearranging gives us

$$v_u = \frac{\lambda(1+r)\,z\psi\Pr(G|\gamma)\Pr(\gamma)}{r\left[r+\lambda+z\psi\Pr(\gamma)\right]}$$

The proof of Proposition 3 (equation (13)) also tells us that a β-agent's net benefit of a lying and running her current green project as green rather than searching is

$$v_g(\beta) - v_u = \frac{\lambda(1+r)\Pr(G|\beta) - rv_u}{r+\lambda}$$

Substituting for v_u and rearranging gives us

$$v_g(\beta) - v_u = \lambda\left(\frac{1+r}{r+\lambda}\right)\left\{\frac{\Pr(G|\beta)(r+\lambda) - z\psi\Pr(\gamma)\left[\Pr(G|\gamma) - \Pr(G|\beta)\right]}{r+\lambda+z\psi\Pr(\gamma)}\right\}$$

This is clearly strictly decreasing in ψ. Moreover, in the limit when $\psi = 0$, this expression is always strictly positive, i.e., when information is perfectly persistent, β-agents always lie and choose green whenever principals reject blue projects. ■

References

Aghion, P. and P. Bolton (1992). An incomplete contracts approach to financial contracting. Review of Economic Studies *59*(3), 473–94.

Brandenburger, A. and B. Polak (1996). When managers cover their posteriors: Making the decisions the market wants to see. RAND Journal of Economics *27*(3), 523–541.

Burdett, K. and M. G. Coles (1997). Marriage and class. Quarterly Journal of Economics *112*(1), 141–168.

Burdett, K., R. Imai, and R. Wright (2004). Unstable relationships. Frontiers of Macroeconomics *1*(1), Article 1.

Burdett, K. and R. Wright (1998). Two-sided search with non-transferable utility. Review of Economic Dynamics *1*(1), 220–245.

Cummins, J. G. and I. Nyman (2005). The dark side of competitive pressure. RAND Journal of Economics *36*(2), 361–397.

Farrell, J. and S. Scotchmer (1988). Partnerships. Quarterly Journal of Economics *103*(2), 279–297.

Gentzkow, M. and J. M. Shapiro (2006). Media bias and reputation. Journal of Political Economy *114*(2), 280–316.

Hart, O. (1995). *Firms, Contracts, and Financial Structure.* New York: Oxford University Press.

Hiroshi, A. (2003). A search model of two-sided matching under non-transferable utility. Journal of Economic Theory *113*(2), 182–198.

Legros, P. and A. F. Newman (2007). Beauty is a beast, frog is a prince: Assortive matching with nontransferabilities. Econometrica *75*(4), 1073–1102.

Pissarides, C. A. (2000). *Equilibrium Unemployment Theory* (2nd ed.). Cambridge: MIT Press.

Prendergast, C. (1993). A theory of 'yes men'. American Economic Review *83*(4), 757–70.

Rogerson, R., R. Shimer, and R. Wright (2005). Search-theoretic models of the labor market: A survey. Journal of Economic Literature *43*(4), 959–988.