On Broadway and sports: how to make a winning team*

By Roland Bel[†], Vladimir Smirnov and Andrew Wait[‡]

August 16, 2013

Abstract

A successful organization – or Broadway production – needs the right team. A potential issue is that incumbent workers in a team might have a lower marginal return of effort, reducing the incentive for them to invest relative to newcomers. While agents always prefer to be teamed with others they have worked with before, a principal may wish to use new team members; this occurs when the loss from lower investment is sufficiently large. In fact, a principal may select a team of newcomers even when incumbents produce greater surplus. These insights have implications for job rotation, centralization-versus-decentralization and mergers.

Key words: experience, team composition, task allocation, job rotation, holdup.
JEL classifications: D21, L23

*We would like to thank Murali Agastya, Macro Alderighi, Nicolas de Roos, Robert Gibbons, Mark Melatos, Jonathan Newton, Hongyi Li, Simon Loertscher, Bonnie Nguyen, Suraj Prasad, Abhijit Sengupta, Kunal Sengupta, John Van Reenen, Don Wright and participants at the ESAM Meetings 2011, the International Industrial Organization Conference in Boston 2011, the Australasian Theory Workshop 2013 and the Organizational Economics Workshop 2013 for their helpful comments. Roland Bel would like to thank University of Sydney for their support and hospitality. The authors are responsible for any errors.

[†]KEDGE Business School, Marseille, France. roland.bel@kedgebs.com.

[‡]School of Economics, University of Sydney, NSW 2006, Australia. vladimir.smirnov@sydney.edu.au; andrew.wait@sydney.edu.au.

1 Introduction

What does it take for success on Broadway? A Broadway production needs: a composer; a lyricist; a librettist who writes the dialogue and plot; a choreographer; a director; and a producer. But who should fulfill these roles? Analyzing Broadway shows between 1877 and 1990, Uzzi & Spiro (2005) find that financial and critical success is increasing in the number of the team members who previously worked together (incumbents), but only up to a point; too many incumbents decrease the likelihood of a production's success. Therefore, the most successful teams comprise some incumbents, but also some newcomers.

Incumbents have some natural advantages. They understand how each other works; they know others' strengths, weaknesses and communication idiosyncracies. Familiar team members often have a better sense of what the others will like and dislike, helping agents to avoid proposing and arguing for ideas that will never be part of the final product. Given the advantage of incumbents, why choose newcomers? Uzzi & Spiro (2005) emphasize that new team members bring fresh ideas to the collaborative effort, increasing overall quality. We focus on a similar rationale for using unfamiliar agents who are inherently less experienced in working together; experience can decrease the incentive for agents to invest, ultimately reducing total output (or quality). In this framework we examine the preferred team composition (incumbents or newcomers) for the principal and the teammates themselves, and relate our findings to a variety of applications.

To analyze the choice of team composition we make two key assumptions: contracts are incomplete, creating an underlying hold-up problem; and final output depends on both the team experience of the workers and the efforts they make. Importantly, in equilibrium, each worker's choice of effort depends on the potential synergy between team members.

In our model, a principal decides whether a team is made up of two agents who have worked together before (incumbents) or, alternatively, two agents with no previous work history together (newcomers).[1] Once chosen, each

[1] Note, we are explicitly referring to experience or familiarity of agents working together;

team member makes a non-contractible effort. After these efforts are sunk, all parties negotiate and receive their share of ex post surplus. Incumbent workers, by their very nature, produce greater output for any given level of effort. On the other hand newcomer agents, because they have never worked together before, have a relatively smaller synergy between them. We make the following important assumption: the additional synergy generated using incumbent agents relative to newcomers is decreasing in worker effort. In other words, newcomers can (partially) make up for the smaller synergy they enjoy by exerting effort. As a result, there is a tradeoff when choosing the team; while incumbents produce more surplus for any given level of effort, newcomers put in more effort in equilibrium. This tradeoff gives rise to several results. First, the (second-best) welfare maximizing team could include either incumbents or newcomers. Second, a principal may opt for a team of either incumbent or rookie workers. Furthermore, while a principal will never choose incumbent agents when newcomers produce more net surplus, a principal could opt for newcomers too often, failing to maximize welfare. Third, workers themselves always prefer teams of incumbents, even when welfare is maximized with rookie team members.

There are many applications of our model. The model is directly relevant to team composition and job rotation.[2] Job rotation, by its very nature, breaks up old relationships and makes workers start afresh with at least some new members. This practice is used by many consulting firms; McKinsey & Company, for example, insists on rotating senior management roles. Our model suggests there are potential benefits from committing to a job-rotation policy, as the agents themselves, if left to their own devices, will always choose to be paired with a familiar (incumbent) partner even if a team of unfamiliar newcomers produce more. This could also be suggestive as to why some firms

in this sense 'experience' means experience on a particular team, and not to their knowledge or skills in the profession more generally. Similarly, 'newcomer' refers to a new member of *that* team, not an inexperienced worker, *per se*.

[2]Other explanations for job rotation include: eliciting information from agents (Arya & Mittendorf 2004); avoiding worker boredom (Azizi et al 2010); and limiting scope for corruption (Choi & Thum 2003).

use predetermined rotation rules, so as to avoid influence costs (Milgrom & Roberts 1990). In a similar manner to the Broadway study mentioned above, Guimera et al (2005) find that the inclusion of newcomers in research teams increases the probability of a successful scientific collaboration in social psychology, economics, ecology and astronomy.

In another situation, some airlines integrate a permutation constraint in their cabin crew assignment algorithm that prevents familiar pilots from being assigned together on the same flight.[3] There is likely to be a potential additional synergy between familiar workers – for instance, crew members who know each other well probably communicate more easily – but these airlines explicitly forgo this synergy. Crew that know each other well may be dissuaded from undertaking the same level of effort when teamed with each other (checking and cross checking and so on) than when teamed up with a stranger. With lower effort, the outcome (in terms of safety incidents) could be worse when familiar agents are paired together, despite the natural synergy. In a similar way, across a range of sports, even highly successful teams bring in new players (particularly in the off-season). Rotation of the team in our model does not rely on the need to replace deadwood or to achieve the right balance of skills; rather, our model suggests a tradeoff between experience and energy. The incumbent members know the team plays, structure, and so forth, so rotating the roster forgoes the synergies that have been built up in the past. But new team members illicit greater effort from all players, old and new alike, and effort is crucial for sporting success.

The tradeoff we present also relates to the allocation of decision-making rights. As noted, if they can, agents tend to choose to work with other incumbent agents too often, whereas a principal can have too much incentive to choose newcomers. This has implications for how the choice of agents is made. If encouraging effort is crucial, centralization could be preferred; the principal can commit to allocating newcomer agents to the task when the agents themselves cannot do so. For example, a sporting team manager can credibly commit to select new players to the squad, something the players themselves

[3] Anonymous industry source.

cannot do. Similarly, a Broadway production might also use centralized decision making, having a project leader tasked with assembling the team. A decentralized decision-making structure could be preferred when capturing the intrinsic synergy between agents is relatively more important than inducing greater effort. Agents often choose their team-mates in rock bands and study groups.

The foundation for our analysis is essentially a moral-hazard-in-teams model (see Alchain & Demsetz 1972, Holmstrom 1982 and Che & Yoo 2001, for example). Given the externality between team members, there is always underinvestment in effort. In our paper, however, there is an additional consideration – the choice of team membership. This means that the principal also needs to take into account how the composition of the team affects agents' incentives. Our analysis suggests that the additional synergy between familiar agents can foster (relative) indolence. If this is the case, choosing unfamiliar newcomers might be preferred as such an arrangement leads to greater levels of effort (and surplus).[4]

This idea has much in common with what social psychologists refer to as 'social loafing' or the 'Ringelmann effect' (see West 2004), a phenomenon observed in experiments by Ringelmann in the late 19th Century. Ringelmann found that people put in 75 per cent of the effort pulling a rope when they thought they were a member of a team of seven (they were blindfolded) compared with their effort as an individual undertaking the same activity (see Kravitz and Martin 1986).[5] This literature also makes a second observation: the types of individuals in the group make a difference to observed effort. For instance, Stroebe et al (1996) examine teams working on complex problems. While team performance exceeded that of individuals, performance was fur-

[4]Team membership has also been explained by the technological complementarities between tasks (Brickley et al 2009) or arising from a multi-tasking incentive problem (see Holmstrom & Milgrom 1991 and Corts 2006, for example).

[5]Other experiments have found similar effects: people shouted in a team with only 74 per cent of the effort as they did individually (Ingham et al 1974); when solving mathematical problems individuals took on average five minutes, groups of 2 individuals took an average of 3-and-a-half minutes per-person and groups of 4 averaged 12 minutes per-person (Shaw 1932).

ther improved when high-ability team members thought they were matched with a low-ability partner.[6] The predictions of our model are consistent with both of these findings: (i) people underinvest when they work as part of a team; and (ii) effort is lower when (high-ability) agents with a large potential synergy are paired together, relative to a team with a small synergy (one high- and one low-ability worker).

There is an existing literature that examines incentive-contract design when there are externalities between agents – see for example, Segal (1999, 2003), Bernstein and Winter (2012) and Winter (2004, 2006). These models typically investigate optimal contracting when the potential externalities are fixed (that is, they do not vary with effort). In contrast to most of these models, we focus on the tradeoff between effort and the relationship between agents, so that the externality varies endogenously in equilibrium. The paper in this literature most similar to ours is Winter (2012), who examines how the structure of information inside a firm affects agents' optimal incentive contracts. Specifically, he finds that creating an environment with greater information is beneficial when agents' efforts are complementary. This is because the dissemination of information about agents' effort (or lack thereof) can allow for effective punishment. The similarities in the two papers are that the work environment affects investment incentives. In Winter (2012) it is the flows of information; in our model it is the composition of the team. One key difference is that Winter explicitly considers incentive contracts based on output, whereas ours is an incomplete contract model in which each party's share of surplus arises from ex post renegotiation.

In a different context, Franco et al (2011) consider how worker types are matched, when this choice affects the optimal incentive contracts, which depend on type and output. They find that a principal might prefer to forgo technological complementarities (by not matching two low-cost workers together) if this allows for a better outcome in terms of effort and the cost

[6] Social psychologists have invoked various explanations for this phenomenon, including: individuals feeling that they would be embarrassed if it were revealed they put in more effort than others; coordination failures; loud talkers drowning out others; and individuals reducing their effort if they feel it will not be adequately recognized (West 2004).

of incentive compensation.[7] Their result – that positive associated matching need not hold once effort and incentive contracts are considered – parallels our result that team-rookies might be preferred. Note also that like in Franco et al (2011) our focus here is on the incentives created when choosing different team structures; we do not focus on issues of matching that arise with unobservable worker type, such as in Jeon (1996), Newman (2007) and Thiele & Wambach (1999).

Winter (2009) studies a related moral-hazard-in-teams problem, in which higher incentives can induce lower efforts – a phenomenon he calls incentive reversal. This can occur when a larger payoff induces one agent to always invest, which in turn can generate an opportunity for other agents to free-ride.[8] We can also generate incentive reversal in our model, although we have a different mechanism at play. With incumbents there is greater surplus for any given level of effort than with newcomers; this is akin to the larger payoffs studied in Winter (2009). This additional surplus may lead incumbent workers to put in less effort, which is similar to incentive reversal. However, in our paper we go further and show that in equilibrium incumbents, despite their natural synergy, can produce (and share) less output than newcomers. That is, not only do incumbent agents exert less effort but they produce less output despite having a natural synergy between them.

2 The Model

Consider a model with a principal P and two agents, A_1 and A_2.[9] P owns an asset that is necessary for production and the two agents can use this asset to produce the final output or surplus. Each agent can expend some specific effort $e_i \in [0, \overline{e}_i)$[10], for $i = 1, 2$, with a cost of $C_i(e_i)$, where: $C_i(0) = 0$; $C_i(e_i)$ is twice differentiable; strictly increasing; and strictly convex in e_i. Thus, the

[7] Kaya & Vereshchagina (2010) make a similar point regarding moral hazard in partnerships.

[8] Klor et al (2012) investigates incentive reversal further through a series of experiments.

[9] This model can be extended in terms of the number of agents.

[10] Note that $\overline{e}_i > 0$ and it is possible that $\overline{e}_i = \infty$.

marginal cost of effort is increasing with the level of investment, as summarized in Assumption 1.

Assumption 1. The cost function $C_i(e_i)$ is non-negative, twice differentiable, strictly increasing in e_i and strictly convex; i.e., $C_i(e_i) \geq 0$, $C_i(0) = 0$, $C_i'(e_i) > 0$ and $C_i''(e_i) > 0$ for $e_i \in [0, \overline{e}_i)$ with $C_i'(0) = 0$ and $\lim_{e_i \to \overline{e}_i} C_i'(e_i) = \infty$ for $i = 1, 2$.

Each agent, making his or her investment e_i and working with the asset, can generate individual surplus of $v_i(e_i)$ for $i = 1, 2$, respectively, as detailed below.

Assumption 2. The surplus v_i is a non-negative, increasing and concave production function; that is, $v_i(e_i) \geq 0$, $v_i(0) = 0$, $v_i'(e_i) \geq 0$ and $v_i''(e_i) \leq 0$ for $i = 1, 2$.

The agents can also work together as a team. If the agents work together they produce a joint surplus v_{12}, where $v_{12}(e_1, e_2, x) > v_1(e_1) + v(e_2)$. The additional surplus produced with joint rather than individual production is the potential synergy $S(e_1, e_2, x)$ between the two agents. The synergy between the workers is defined below, which also allows us to differentiate between two types of agent: an *incumbent* and a *newcomer*.[11]

Definition 1. $S(e_1, e_2, x) = v_{12}(e_1, e_2, x) - v_1(e_1) - v(e_2)$ represents the synergy between two agents, who can be: (a) *incumbents* if $x = 1$; or (b) *newcomers* if $x = 0$.

For notational convenience we label $S_1(e_1, e_2) \equiv S(e_1, e_2, 1)$ for incumbent team members, $S_0(e_1, e_2) \equiv S(e_1, e_2, 0)$ for newcomers and $\Delta S(e_1, e_2) \equiv S_1(e_1, e_2) - S_0(e_1, e_2)$. We also make the following assumption regarding the nature of the synergy between agents.

[11] As noted in the introduction, the term incumbent refers to an agent who has worked with his teammate before; on the other hand, a newcomer refers to an agent with no working experience with their particular teammate.

Assumption 3. The synergy for both incumbents and newcomers is positive and non-decreasing in effort. In addition, the relative synergy for an incumbent team compared with newcomers is non-negative and non-increasing with effort. That is, $S_1(e_1, e_2) \geq S_0(e_1, e_2) > 0$ and $\frac{\partial S_0(e_1,e_2)}{\partial e_i} \geq \frac{\partial S_1(e_1,e_2)}{\partial e_i} \geq 0$ for $i = 1, 2$, $\forall$ e_1, e_2.

Assumption 3 makes several substantive points. First, each of the two types of agents – incumbents or newcomers – are complementary in the sense that the team synergy is positive and non-decreasing in effort. Second, for a given level of effort a team of incumbents always produces at least as much output as a team of newcomers. For instance, consider the case of two incumbent agents who have previously worked with one another and who know each other very well. Because they understand each other they can effectively coordinate their activities. On the other hand, two newcomers will not know each other. Given they have no working history, there is no previous relationship the two can rely on. This means there will be a few difficulties learning how to work together, and for a given level of effort the two strangers will produce less output than two team veterans who are used to working together.

Third, even though the team synergy is always non-decreasing in effort for both team compositions, the relative advantage of incumbents is (weakly) decreasing in effort. In other words, two newcomers can partially overcome their relative disadvantage by working and learning the specific attributes of their fellow team member. That is, newcomers can learn about the other agent's strengths, weaknesses, how they communicate, and so on. As the two newcomers put in more effort, the relative advantage of the incumbents, while still there, becomes smaller.

Finally, we would like the profit-maximization problem when agents work together to be well defined, which requires that v_{12} is concave. This is summarized below.

Assumption 4. $v_{12}(e_1, e_2, x)$ is non-negative, increasing and concave in $e = (e_1, e_2)$; that is, $v_{12}(e_1, e_2, x) \geq 0$, $\frac{\partial v_{12}(e_1,e_2,x)}{\partial e_i} \geq 0$, $\frac{\partial^2 v_{12}(e_1,e_2,x)}{\partial e_i^2} \leq 0$ and $\frac{\partial^2 v_{12}(e_1,e_2,x)}{\partial e_1^2} \frac{\partial^2 v_{12}(e_1,e_2,x)}{\partial e_2^2} - \left(\frac{\partial^2 v_{12}(e_1,e_2,x)}{\partial e_1 \partial e_2}\right)^2 \geq 0$ for $i = 1, 2$ and $x = 0, 1$.

Note that for Assumption 4 to hold it is sufficient (but not necessary) that the synergy between either two incumbents or two newcomers is relatively small compared with the individual surpluses of v_1 and v_2. It is also sufficient that the synergy itself is a concave function for the two different types of team.

2.1 Timing and investment solution

The game has the following timing. At date 0, the type of workers on the team is chosen; specifically, it is decided whether the team should comprise of incumbent or newcomer agents. At date 1, these agents choose their level of relationship-specific non-contractible effort. Finally, at date 2, the agents and principal bargain over their share of surplus. Figure 1 summarizes the timing.

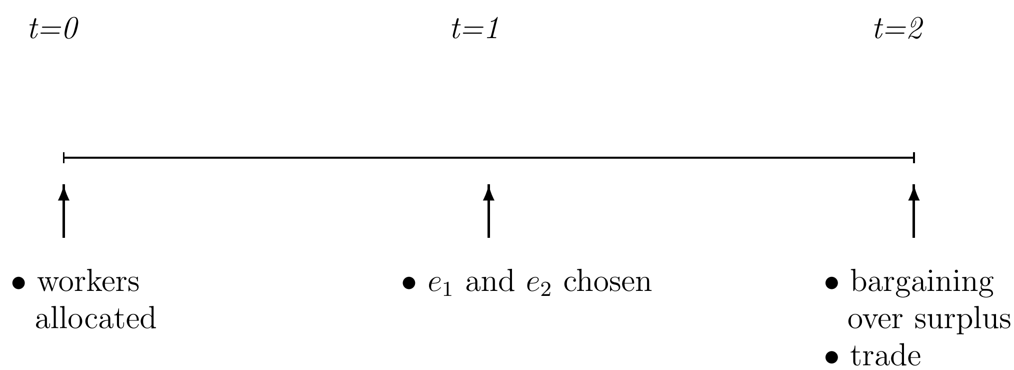

Figure 1: Timing of the game

Following the literature, we assume that ex post surplus is distributed according to the Shapley value. Furthermore, no date 1 variable is contractible at date 0. Let M be the sub-coalition of the grand coalition of all $N = 3$ agents. Following bargaining, each party $j = 1, 2, P$ receives a share of ex post surplus B_j so that the sum of the distributed shares is equal to the total available surplus in the grand coalition, so that

$$\sum_{j \in N} B_j(e_1, e_2, x) = v_{12}(e_1, e_2, x). \tag{1}$$

In a similar way to Hart and Moore (1990), the Shapley value $B_j(e_1, e_2, x)$ is defined as follows.

Definition 2. Party $j's$ share of gross surplus is given by the Shapley value

$$B_j(e_1, e_2, x) = \sum_{M|i \in M} p(M)[v(M \mid e_1, e_2, x) - v(M \backslash \{i\} \mid e_1, e_2, x)], \qquad (2)$$

where $p(M) = \frac{(|M|-1)!(|N|-|M|)!}{(|N|)!}$.

Note that because the game is convex the Shapley value is always in the core.[12]

3 The incentives to invest

There will be different incentives to invest, depending on whether the team is composed of newcomers or incumbents. In this section we compare investment incentives and the welfare implications of the two alternative team structures. To provide a benchmark for these comparisons, we first analyze the first-best team structure.

3.1 First-best incentives

Let us compare the first-best incentives and the choice between incumbent and newcomer agents. The total net surplus is $v_{12}(e_1, e_2, x) - C(e_1) - C(e_2)$ and the first-best investments e_1^* and e_2^* solve:

$$\frac{\partial v_i(e_i)}{\partial e_i} + \frac{\partial S(e_1, e_2, x)}{\partial e_i} = \frac{\partial C_i(e_i)}{\partial e_i}, \ \forall \ i = 1, 2, \ \ x = 0, 1. \qquad (3)$$

The solution for each agent's investment choice exists and is unique given Assumptions 1,2 and 4. Note that, given $\Delta S(e_1, e_2) \geq 0 \ \forall \ e_1, \ e_2$, both total and net surplus are always weakly higher with incumbent rather than with rookie agents. This means net surplus is maximized using incumbents.

[12] See Osbourne and Rubinstein (1990, exercise 295.5), for example.

Result 1. The first-best outcome always entails using incumbents rather than newcomers.

Proof. The proof follows from the discussion above. $\square$

As $\Delta S \geq 0$, total surplus is weakly higher with incumbent agents – for any level of effort, a switch from newcomers will increase gross surplus without altering costs. If an enforceable contract can be written on effort, using incumbents is always optimal.

3.2 Second-best incentives

As a complete contract cannot always be written, consider the investment decision of the two workers taking into account ex post bargaining. Since the principal is indispensable and at least one of the agents is indispensable[13], the ex ante payoff given by the Shapley value for each agent is[14]:

$$\frac{1}{2}v_i(e_i) + \frac{1}{3}S(e_1, e_2, x) - C_i(e_i), \;\; \forall \;\; i = 1, 2. \tag{4}$$

Anticipating renegotiation, incumbent agents will set their effort to maximize their ex ante payoff. The equilibrium levels of effort e_1^I and e_2^I solve the following first-order conditions:

$$\frac{1}{2}v_i'(e_i) + \frac{1}{3}\frac{\partial S_1(e_1, e_2)}{\partial e_i} = \frac{\partial C_i(e_i)}{\partial e_i}, \;\; \forall \;\; i = 1, 2. \tag{5}$$

On the other hand, if the agents are newcomers, their equilibrium levels of investment e_1^N and e_2^N are given by:

$$\frac{1}{2}v_i'(e_i) + \frac{1}{3}\frac{\partial S_0(e_1, e_2)}{\partial e_i} = \frac{\partial C_i(e_i)}{\partial e_i}, \;\; \forall \;\; i = 1, 2. \tag{6}$$

Similar to the first-best case, the solution for each agent's investment choice

[13] An assumption that the two team members are indispensable would alter the shares each party receives but leads to the same qualitative tradeoffs.

[14] See the Appendix for a detailed derivation of the shares of gross surplus for the agents and the principal.

exists and is unique due to Assumptions 1, 2 and 4. Moreover, given Assumptions 2 and 3 it follows that:

$$e_i^I \leq e_i^N, \ \ \forall \ i = 1, 2, \tag{7}$$

as summarized below.

Result 2. An agent exerts a lower level of effort when paired with another incumbent rather than a newcomer; that is, $e_i^I \leq e_i^N, \ \forall \ i = 1, 2$.

This leads to the following Corollary that we will make use of in our subsequent analysis.

Corollary 1. $\Delta C_i(e_i) = C_i(e_i^N) - C_i(e_i^I) \ \forall \ i = 1, 2$ *is always non-negative.*

Equilibrium effort – and effort cost – is always greater for an agent paired with another rookie team member rather than a worker who she has had previous experience with. This result follows because the marginal return from effort is lower with incumbent agents; that is, the relative size of the synergy for veteran workers over their greenhorn counterparts – is decreasing in effort (Assumption 3).

In addition, it is worth noting that newcomers can invest more than the first-best level of effort. Due to the underlying hold-up problem there is always underinvestment, irrespective of the type of team chosen. However, the first-best team is always composed of incumbents. It can be the case then that the equilibrium level of effort chosen by newcomers e_i^N is more than the optimal level of effort based on using a veteran team. We illustrate this point in Example 1.

3.3 The principal's choice of team composition

We now consider the principal's choice of team-mates. It follows that, when the surplus generated by greater effort is relatively more important than protecting the relative synergy of incumbents, the ex post surplus may be higher with newcomers rather than with incumbent agents. At date 0, the principal will choose to select two incumbent (newcomer) agents if and only if:

$$\frac{1}{2}v_1^N + \frac{1}{2}v_2^N + \frac{1}{3}S_0^N \leq (\geq) \frac{1}{2}v_1^I + \frac{1}{2}v_2^I + \frac{1}{3}S_1^I, \tag{8}$$

where for notational convenience, we denote S_1^I as the team synergy generated when incumbents invest e_1^I and e_2^I and S_0^N as the synergy generated when newcomers invest e_1^N and e_2^N. We also simplify notation by indicating the effort level as a superscript in each value function.[15]

Examining this equation, if $S_0^N \geq S_1^I$ the principal will always use newcomers. The interesting case, however, is when there is a tradeoff for the principal between using incumbents or newcomers. This happens when the equilibrium synergy of newcomers is less than the equilibrium synergy of incumbents. From hereon, we use the following assumption.

Assumption 5. The equilibrium synergy of incumbents is greater than the equilibrium synergy of newcomers; that is, $S_1^I > S_0^N$.

Note that for this assumption to hold it is sufficient (but not necessary) that the increase in the newcomer synergy with respect to effort is not too high, relative to the difference in synergy.[16]

Now consider the payoff to each agent when matched with either an incumbent or a newcomer as their fellow co-worker. Using a revealed-preference argument, if an agent is paired with an incumbent partner, the agent i's payoff will be at least as large with a choice of effort e_i^I rather than with a choice of e_i^N. The same argument can be made for an agent on a newcomer team – e_i^N yields at least as much for an agent in a rookie team as does exerting e_i^I. Following this logic, the rational choice of individual i ensures that:

$$\frac{1}{2}v_i^N + \frac{1}{3}S_1(e_1^N, e_2^I) - C_i(e_i^N) \leq \frac{1}{2}v_i^I + \frac{1}{3}S_1^I - C_i(e_i^I), \ \forall \ i = 1, 2; \tag{9}$$

[15]Note that for ease of exposition we allow the principal to choose either team structure if the equation holds with equality.

[16]This condition is satisfied for production and cost functions typically used. Indeed, we had difficulty finding any explicit function for which this assumption does not hold. For instance, see Example 1.

and

$$\frac{1}{2}v_i^N + \frac{1}{3}S_0^N - C_i(e_i^N) \geq \frac{1}{2}v_i^I + \frac{1}{3}S_0(e_1^I, e_2^N) - C_i(e_i^I), \ \ \forall \ i = 1, 2. \tag{10}$$

Summing for both agents, these two conditions are:

$$\frac{1}{2}v_1^N + \frac{1}{2}v_2^N + \frac{2}{3}S_1(e_1^N, e_2^I) - \Delta C_1(e_1) - \Delta C_2(e_2) \leq \frac{1}{2}v_1^I + \frac{1}{2}v_2^I + \frac{2}{3}S_1^I \tag{11}$$

and

$$\frac{1}{2}v_1^N + \frac{1}{2}v_2^N + \frac{2}{3}S_0^N - \Delta C_1(e_1) - \Delta C_2(e_2) \geq \frac{1}{2}v_1^I + \frac{1}{2}v_2^I + \frac{2}{3}S_0(e_1^I, e_2^N). \tag{12}$$

Comparing (8) and (11), a sufficient condition for choosing incumbent agents is:

$$\Delta C_1(e_1) + \Delta C_2(e_2) \leq \frac{2}{3}S_1(e_1^N, e_2^I) - \frac{1}{3}S_1^I - \frac{1}{3}S_0^N. \tag{13}$$

Given Assumption 3, it follows that $S_1(e_1^N, e_2^I) \geq S_1^I$. This means the following condition ensures that (13) is satisfied

$$\Delta C_1(e_1) + \Delta C_2(e_2) \leq \frac{1}{3}S_1^I - \frac{1}{3}S_0^N, \tag{14}$$

where $S_1^I > S_0^N$ from Assumption 5. For convenience this condition can be rewritten as

$$X \leq \frac{1}{3}, \tag{15}$$

where we introduce the following notation $X = \frac{\Delta C_1(e_1)+\Delta C_2(e_2)}{S_1^I - S_0^N}$.

Comparing (8) and (12), it turns out that a sufficient condition for choosing newcomers is:

$$\Delta C_1(e_1) + \Delta C_2(e_2) \geq \frac{1}{3}S_1^I + \frac{1}{3}S_0^N - \frac{2}{3}S_0(e_1^I, e_2^N). \tag{16}$$

Given Assumption 3, it follows that $S_0(e_1^I, e_2^N) \geq S_0^I$, where we denote S_0^I as the synergy generated when newcomer agents invest e_1^I and e_2^I. This means the following condition ensures that (16) is satisfied

$$\Delta C_1(e_1) + \Delta C_2(e_2) \geq \frac{1}{3}S_1^I + \frac{1}{3}S_0^N - \frac{2}{3}S_0^I, \tag{17}$$

which is

$$X \geq \frac{1}{3} + \frac{2}{3}Y, \tag{18}$$

where we introduce the following notation $Y = \frac{S_0^N - S_0^I}{S_1^I - S_0^N}$. Note, from Assumptions 3 and 5, $Y \geq 0$.

In summary, we have outlined the sufficient conditions for the principal to use incumbent agents and, secondly, when she will choose newcomers. These conditions are detailed in the following result.

Result 3. A sufficient condition for the principal to choose incumbent agents is that $\Delta C_1(e_1) + \Delta C_2(e_2) \leq \frac{1}{3}S_1^I - \frac{1}{3}S_0^N$, while the sufficient condition for principal to choose newcomers is that $\Delta C_1(e_1) + \Delta C_2(e_2) \geq \frac{1}{3}S_1^I + \frac{1}{3}S_0^N - \frac{2}{3}S_0^I$.

Figure 2 shows the potential level of output with the two alternative team structures. Focusing on e_1 (and suppressing the role of e_2 for exposition), $v_1 + v_2 + S_1$ is the potential surplus with veteran agents, while $v_1 + v_2 + S_0$ is the potential surplus with newcomers. From Assumption 3, the additional synergy that incumbent agents generate (relative to newcomers) is (weakly) monotonically decreasing in effort e_1. This means that the marginal return of e_1 is less for a veteran worker; consequently, their equilibrium investment level is $e_1^I \leq e_1^N$. Hence, there is a tradeoff for the principal; the additional synergy with incumbent workers must be compared with the additional surplus generated by the higher effort put forth by new team members. Critically, this comparison needs to be made at the equilibrium levels of effort for the two alternatives. The principal will choose to allocate the type of agents that will maximize her return, which is her share of gross surplus at renegotiation, and this could be either incumbents of newcomers.

It is worth comparing this result with Proposition 3 in Che and Yoo (2001).

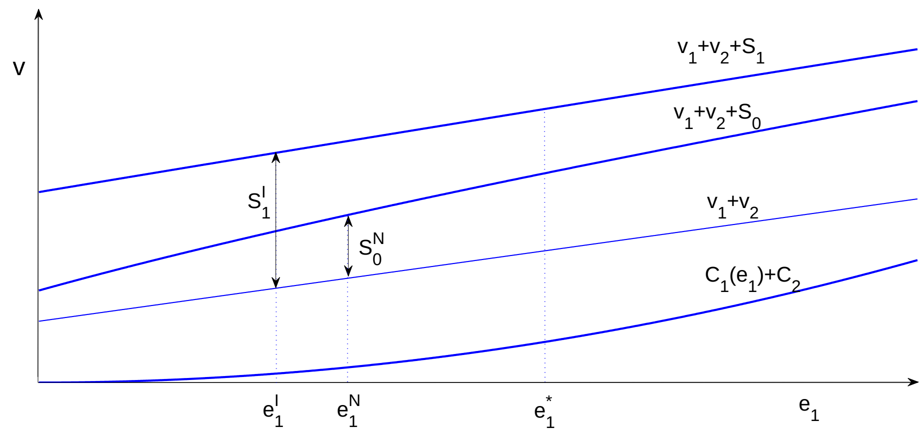

Figure 2: Surplus with incumbent and newcomer team members

They find that a principal will opt for individual rather than team production if there is no synergy between the workers. In contrast, our result suggests that a principal might opt for newcomer agents even when incumbents produce a larger synergy, provided there is a sufficient change in effort.

3.4 The agents' choice of team structure

We now turn to the preferences of the agents themselves as to the makeup of their team. Agent i will choose to be paired with a fellow incumbent if:

$$\frac{1}{2}v_i^N + \frac{1}{3}S_0^N - \Delta C_i(e_i) \leq \frac{1}{2}v_i^I + \frac{1}{3}S_1^I \tag{19}$$

for $i = 1, 2$. Given (9), and

$$S_0^N < S_1^I < S_1(e_1^N, e_2^I),$$

this inequality will always hold, ensuring that the agents themselves will always want to be paired with a veteran partner.

Result 4. Agents always want to be in an incumbent team.

Agents always prefer fellow incumbent workers in their team, as being paired with another veteran allows an agent to enjoy a share of the larger intrinsic synergy that is forthcoming in incumbent teams. It also allows the agents to reduce their effort in equilibrium, of which they receive the full savings.

3.5 Second-best optimal choice of team structure

We showed earlier that a principal might choose to use newcomer agents, forgoing the additional synergy generated between veteran team members. Now consider the choice of team composition made by a social planner, whose goal is to maximize (second-best) total welfare, given each agent's choice of equilibrium effort. In particular, this allows us to compare the welfare maximizing team composition to the principal's choice.

Welfare will be higher with incumbent (newcomer) team members if and only if:

$$v_1^N + v_2^N + S_0^N - C_1(e_1^N) - C_2(e_2^N) \leq (\geq) v_1^I + v_2^I + S_1^I - C_1(e_1^I) - C_2(e_2^I). \quad (20)$$

Comparing (11) and (20), it turns out that a sufficient condition for welfare to increase with incumbents is:

$$\Delta C_1(e_1) + \Delta C_2(e_2) \leq \frac{4}{3} S_1(e_1^N, e_2^I) - \frac{1}{3} S_1^I - S_0^N. \quad (21)$$

Given Assumption 3, it follows that $S_1(e_1^N, e_2^I) \geq S_1^I$. Using the same argument as above, if

$$\Delta C_1(e_1) + \Delta C_2(e_2) \leq S_1^I - S_0^N \quad (22)$$

then (21) is satisfied. Inequality (22) can be rewritten as

$$X \leq 1. \quad (23)$$

Comparing (12) and (20), it turns out that a sufficient condition for welfare to increase with newcomers is:

$$\Delta C_1(e_1) + \Delta C_2(e_2) \geq S_1^I + \frac{1}{3} S_0^N - \frac{4}{3} S_0^I, \quad (24)$$

or that

$$X \geq 1 + \frac{4}{3}Y. \tag{25}$$

From the arguments above, we construct sufficient conditions for when newcomer or incumbent agents maximize (second-best) welfare, summarized in the result below.

Result 5. A sufficient condition for total welfare to be higher with incumbents rather than newcomers is that $\Delta C_1(e_1) + \Delta C_2(e_2) \leq S_1^I - S_0^N$. A sufficient condition for total welfare to be higher with newcomers is that $\Delta C_1(e_1) + \Delta C_2(e_2) \geq S_1^I + \frac{1}{3}S_0^N - \frac{4}{3}S_0^I$.

We are now in a position to compare the principal's choice of team composition (Result 3) with the welfare maximizing one (Result 5). To help analyze this issue, consider Figure 3. In this figure, the vertical axis is $Y = \frac{S_0^N - S_0^I}{S_1^I - S_0^N}$, which is the change in the newcomer synergy given e_1^N rather than e_1^I, relative to the difference in equilibrium synergy with incumbents rather than newcomers. The horizontal axis is $X = \frac{\Delta C_1(e_1) + \Delta C_2(e_2)}{S_1^I - S_0^N}$, which is the increase in effort costs associated with newcomers rather than incumbents relative to the difference in equilibrium synergy with incumbents rather than newcomers. Note that we are only interested in area $X \geq 0$, $Y \geq 0$ because of Corollary 1 and Assumption 5.

In the Figure, in region A the principal will always choose incumbents; the condition $X \leq \frac{1}{3}$ indicates the sufficient condition for incumbent workers to be chosen. Similarly, in regions C, E and F the principal will always choose newcomers; the sufficient condition is that $X \geq \frac{1}{3} + \frac{2}{3}Y$. Where neither sufficient condition holds, in areas B and D, depending on the specific cost and production functions either type of team composition could be chosen by P.

From a social planner's perspective, the vertical line $X = 1$ indicates the sufficient condition required for incumbents to produce greater net surplus in equilibrium; veterans are required to maximize surplus in regions A, B and C. The sufficient condition for newcomers to maximize welfare is satisfied in region F (where $X \geq 1 + \frac{4}{3}Y$). Using similar intuition as before, in areas D

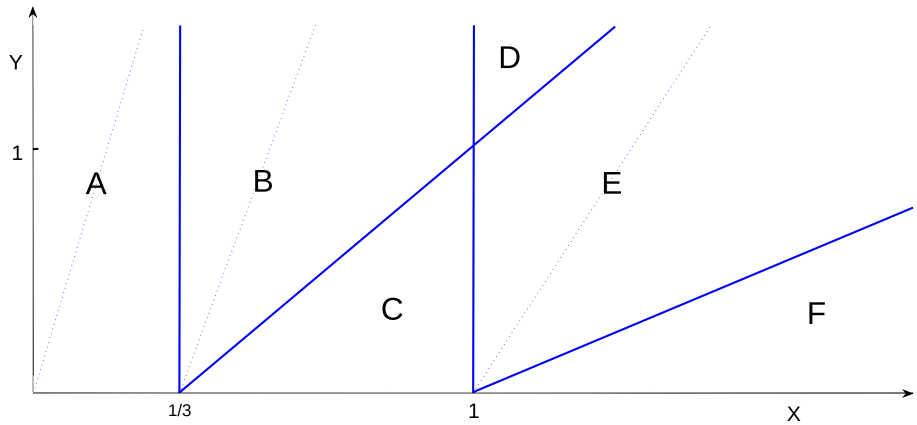

Figure 3: Total welfare and firm choice of newcomers or incumbents

and E either type of team composition could maximize second-best welfare, depending on the specific functions used.

Note that in region C the principal will choose a team of newcomers, but the welfare-maximizing choice is for veterans to be used. From a social welfare point of view, the principal opts for the wrong type of workers. This point is summarized in the following proposition.

Proposition 1. *When $X \in [\frac{1}{3}, 1]$ and $Y \in [0, \frac{3X-1}{2}]$ hold, the principal chooses newcomers, even though (second-best) welfare is maximized by using incumbent workers.*

Proof. The proof follows from the discussion above. $\square$

This suggests that, for some parameter values the principal has too much propensity to choose newcomers. This arises because the principal considers her share of ex post surplus but does not consider the increase in ex ante costs, $\Delta C_1(e_1) + \Delta C_2(e_2)$, as these costs are borne by the agents. If the increase in costs is relatively high as compared with the decrease in the relative size of the team synergy between the newcomer and incumbent levels of effort, the principal tends to choose newcomers too often.

The following example highlights some of the results of the previous discussion.

Example 1

Assume that the coalition containing only one agent i and the principal generates a surplus of $v_i = 2e_i$. The coalition containing two incumbents and the principal generates additional constant surplus of S_1, while the coalition containing two newcomers and the principal generates additional surplus of $S_0 = \min[3\beta(1 + e_1 + e_2), S_1]$, where $\beta > 0$. The costs for both agents are $C_i(e_i) = e_i^2$ for $i = 1, 2$. Assumptions 1-4 are satisfied. In the first-best case, the optimal efforts are $e_1^* = e_2^* = 1$. In the case of newcomers, their individual efforts solve the following system:

$$\begin{cases} 1 + \beta = 2e_1, \\ 1 + \beta = 2e_2. \end{cases} \tag{26}$$

This gives $e_1^N = e_2^N = \frac{1+\beta}{2}$. From equation 6, incumbents choose their efforts to be $e_1^I = e_2^I = \frac{1}{2}$. As we discussed earlier, the newcomers' effort can be larger than the first-best level; specifically, $e_i^N > e_i^*$ if $\beta > 1$.

Given these equilibrium efforts, we can calculate $S_0^N = 3\beta(2 + \beta)$ and $S_0^I = 6\beta$. To ensure Assumption 5 is satisfied, that is $S_1^I > S_0^N$, assume that $S_1 = \alpha S_0^N$, where $\alpha > 1$.

Next, we calculate $\Delta C_1(e_1) + \Delta C_2(e_2) = \frac{(1+\beta)^2}{2} - \frac{1}{2}$. This yields $X = \frac{\Delta C_1(e_1)+\Delta C_2(e_2)}{S_1^E - S_0^U} = \frac{(1+\beta)^2-1}{6\beta(2+\beta)(\alpha-1)} = \frac{1}{6(\alpha-1)}$ and $Y = \frac{S_0^N - S_0^I}{S_1^I - S_0^N} = \frac{3\beta^2}{3\beta(2+\beta)(\alpha-1)} = \frac{\beta}{(2+\beta)(\alpha-1)}$. Dividing X by Y and simplifying yields $Y = \frac{6\beta}{2+\beta}X$. Note that, as $\beta > 0$, all the points with $X > 0$ and $0 < Y < 6X$ are feasible for this specification.[17]

Given the specific functions used, the actual condition for the principal to choose incumbent agents (condition 8) is $Y \geq 6X - 2$, illustrated in Figure 3 by the dashed line that cuts area B. Similarly, the actual condition that characterizes the area in which incumbent workers maximize welfare (condition 20) is $Y \geq 3X - 3$, the dashed line cutting area E. Note that these two dashed

[17]As illustrated in Figure 3, all points to the right of the dashed line that crosses A are feasible. Note that this example uses a relatively simple specification with linear payoffs. Points to the left of this dashed line could be feasible using a specification with strictly concave payoffs.

lines never cross. As we discuss in the next section, this is an illustration of the fact that a principal's choice of incumbents must also maximize second-best surplus. □

3.6 Principal's team choice and total welfare

Next, consider the case when the principal opts to use incumbent workers. As it turns out, if the principal chooses incumbents it is always the case that an incumbent team maximizes social welfare. The intuition for this can be demonstrated with the aid of Figure 2. The principal is concerned about their share of gross surplus (from their Shapley value) from the two alternatives, respectively. If the principal anticipates a higher payoff with veterans it must be the case that incumbents also maximize net surplus because not only incumbent gross surplus is higher than newcomer gross surplus, but effort costs are also lower with incumbents (Corollary 1). This result is captured in the Figure 3 and discussed in Example 1; the two dashed lines crossing areas B and E do not intersect. This discussion is summarized in the following proposition.

Proposition 2. *Whenever a principal chooses incumbents in equilibrium, a social planner would also make the same choice regarding team composition; that is, incumbents are (second-best) welfare maximizing.*

Proof. See Appendix. □

In our framework, if we observe a principal opting for incumbents, this choice also maximizes (second-best) welfare. But as noted in subsection 3.4, agents always prefer to be on a team with someone that they have worked with before. As a consequence, if P chooses incumbents, there is no difference between a centralized (principal) or decentralized (agents-based) decision about team composition; both decision-making structures yield the same outcome.

4 Incentive reversal

As noted in the Introduction, Winter (2009) shows the possibility of incentive reversal in which an increase in the payoffs (incentives) can result in most agents reducing their effort. In this section we show that we can produce equivalent results. In our framework, incentive reversal would be when an improvement in the technology that produces more surplus and returns for each worker, for every level of effort, leads to a decrease in equilibrium efforts of all agents. To make a more direct comparison with Winter (2009), in this section we relax Assumption 3, allowing the relative synergy to be both increasing and decreasing in effort.

Let us first establish the conditions when incentive reversal cannot occur in equilibrium, a parallel result to Proposition 1 in Winter (2009). This is outlined in the following proposition.

Proposition 3. *Equilibrium efforts are immune to incentive reversal if synergies are complementary for all team types and the relative synergy of an incumbent team compared with newcomers is non-negative and non-decreasing with effort; that is,* $S_1(e_1, e_2) \geq S_0(e_1, e_2) > 0$ *and* $\frac{\partial S_1(e_1,e_2)}{\partial e_i} \geq \frac{\partial S_0(e_1,e_2)}{\partial e_i} \geq 0$ *for* $i = 1, 2, \forall\, e_1, e_2$.

Proof. See Appendix. □

In Winter (2009), incentive reversal relies on increasing returns with respect to agents' efforts and it is not possible with decreasing returns. Here, we only consider the case of decreasing returns to scale. In our model, as noted in Proposition 3, incentive reversal will not be observed if the relative synergy for incumbents versus newcomers is always non-negative and non-decreasing in effort. In this case a principal will always choose an incumbent team because not only do incumbents enjoy a larger synergy but they also put in more effort than newcomers.

Incentive reversal is possible in our framework, however, if this is not the case. This is illustrated in the Example below. Moreover, we show that incentive reversal can reduce total welfare and that the principal can choose the structure that produces lower surplus.

Example 2

Let us augment Example 1 by assuming $\alpha = 1.1$ and $\beta \in [0, 10]$. In the case of incumbent agents, the equilibrium efforts are $e_1^I = e_2^I = \frac{1}{2}$, while in the case of newcomers, the equilibrium efforts are $e_1^N = e_2^N = \frac{1+\beta}{2}$. One can see that efforts are smaller for incumbents; that is, there is an incentive reversal. Let us calculate total welfare in the case of incumbent agents

$$W^I = v_{12}(e_1^I, e_2^I) - C_1(e_1^I) - C_2(e_2^I) = 1.5 + 6\alpha\beta + 3\alpha\beta^2; \tag{27}$$

and the principal's payoff

$$P^I = \frac{1}{2}v_1(e_1^I) + \frac{1}{2}v_2(e_2^I) + \frac{1}{3}S(e_1^I, e_2^I) = 1 + 2\alpha\beta + \alpha\beta^2. \tag{28}$$

The total welfare in the case of newcomers is

$$W^N = v_{12}(e_1^N, e_2^N) - C_1(e_1^N) - C_2(e_2^N) = 1.5 + 7\beta + 2.5\beta^2; \tag{29}$$

and the principal's payoff is

$$P^N = \frac{1}{2}v_1(e_1^N) + \frac{1}{2}v_2(e_2^N) + \frac{1}{3}S(e_1^N, e_2^N) = 1 + 3\beta + \beta^2. \tag{30}$$

Figure 4 shows the difference in total welfare, $W^I - W^N$, and the difference in principal's payoff, $P^I - P^N$, both as a function of β. When $\beta \leq \beta_1$ the total welfare is maximized with the newcomers; despite the higher synergy, total welfare is lower with incumbents. On the other hand, incumbent agents produce more surplus in equilibrium if $\beta > \beta_1$. The principal's interests are different, however. When $\beta \leq \beta_2$, the principal prefers newcomers. It is only when $\beta > \beta_2$, that she would opt for incumbents. Importantly, for $\beta_1 \leq \beta \leq \beta_2$ the principal chooses newcomers even though incumbents are welfare maximizing choice, as outlined in Proposition 1. □

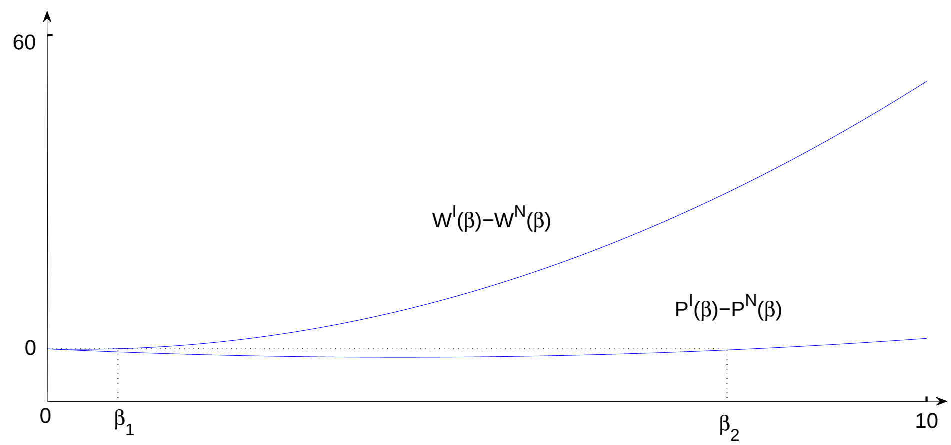

Figure 4: Total welfare and principal's payoff

In Winter (2009), in contrast to our paper, effort is a discrete choice, resulting in a discontinuity in an agent's best-response function. If another party's payoff increases sufficiently so that they have a dominant strategy to invest, an agent's best response might be to switch to low effort. In our model the agents' choice is continuous; incentive reversal arises due to the fact that the rate of the increase in team synergy is smaller for agents with a larger absolute synergy between them, as shown in the Example above. It is important to note that in our model incentive reversal may result in all team members decreasing their effort. This is not possible in Winter (2009) where only a subset of agents decrease their effort.

Given that it may decrease total welfare, incentive reversal is another illustration of how the environment – here the production technology – can affect worker effort and total welfare in a counter-intuitive way. In such a situation a principal, if they could, would opt to not implement the more efficient production technology, realizing its negative impact on overall output after changes in agents' effort are accounted for.

5 Discussion and concluding comments

Getting the right team matters a great deal; simply choosing team mates with the most natural synergy between them is not always the best option. Rather, teams comprising of agents with a lower intrinsic synergy sometimes provide better performance. This could be why workgroups often include rookie members. It is said that a champion team will beat a team of champions. Our analysis suggests that even if a team of champions would perform better *for a given level of effort*, a team of journeymen could outperform them precisely because the less lauded unit has a greater incentive to put in effort (both in training and in the game).

There are several key elements driving our result. First, there is contractual incompleteness in the model, in that the agents cannot write contingent contracts on either surplus or effort ex ante. If parties have the ability to contract on effort, the first-best outcome can be achieved, and incumbent workers will always be used together. However it is often difficult to contract on effort, be it in producing a musical, in sport or business. Second, we assume that the relative synergy when using incumbent workers is decreasing in the effort or investment made; this means that the marginal return from effort – while always positive – is lower for incumbents than it is for newcomer workers. The combination of these effects can together mean that (second-best) surplus is higher with newcomers rather than incumbents. What the model suggests is that the true nature of a synergy needs to be considered in equilibrium – agents that end up producing more output might be the team members who do not necessary intrinsically work best together.[18]

It is also worth noting that our focus has been on the choice between incumbents and newcomers, both of whom enjoy a positive synergy. However, the same point can be made for other types of agents; it is the relative difference in the marginal return of effort that helps determine team structure. For example, a principal may have to choose a team with a positive synergy or

[18]To make things clear, this model examines this tradeoff in a relatively simple setting. In particular, we consider a static model and abstract from the choice of team composition over time. We leave this issue for further research.

agents with no team synergy at all (independent workers). Similarly, the choice could be between independent workers or those who are substitutes at the margin (see Bel (2012)). For both of these two new alternatives, provided that the marginal return of effort is lower for agents with a positive synergy than for ones with no synergy (in the first case), or for the independents rather than substitutes (in the second), the relative differences between the two options are qualitatively the same as the incumbent/newcomer tradeoff examined in our model. That is, for instance, it could be that a firm or principal chooses to hire substitute workers even though they intrinsically produce less output for a given level of effort, provided this choice induces greater effort.[19]

There are many applications of the model. As noted, if incumbency reduces the incentive to invest, it could be that a policy of job rotation increases total surplus (in consulting projects, musical productions or in research projects). When deciding the composition of a team, an organization might wish to choose workers that do not otherwise have the highest possible synergy between them. Note that our result differs from the usual moral-hazard-in-teams result (see Holmstrom 1982 for example); conditional on the type of workers chosen, we get under-investment in our model due to holdup regardless as to the type of worker, but the equilibrium level of effort is determined by the choice of the type of agent in the team. Moreover, it is possible that we can observe overinvestment in equilibrium by a team of newcomers.

Our framework also has implications for the allocation of decision-making rights. A principal can have a tendency to choose newcomers too often; the agents themselves always prefer to have incumbent team-mates, even if newcomers produce greater net surplus. This suggests that when inducing greater effort (from newcomers) is more important, the choice of team should be made centrally by the principal; on the other hand, when taking advantage of a natural synergy is more important, it might be advantageous for the principal to commit not to get involved, having the decision decentralized to the agents

[19] One example we have in mind is a firm hiring a difficult or obnoxious worker – their presence might naturally hinder output relative to a more congenial colleague, but this could be made up for if their presence on the team creates an additional incentive to work harder.

themselves.

Our model also applies to the joint use or co-location of assets. Using some assets together rather than separately can generate an additional natural synergy, but this could also change parties' incentives to engage in ex ante investment. The standard predictions in the property-rights models (Hart and Moore 1990 and Hart 1995 for example) suggest that complementary assets should be owned together, so as to provide the best possible incentives for ex ante investment. Our model generates results in the same vein as Bel (2012), who finds that assets with a positive synergy need not be owned together when they are substitutes at the margin. Unlike Bel (2012), however, we do not assume that the investments by incumbents are substitutes at the margin. In our model both incumbents and newcomers enjoy a positive synergy that is increasing with effort. Rather, it is the relative difference in the synergy that drives our result.

Another question is who should decide which assets are to be used together? The decision could be centralized to a principal, perhaps under the auspices of one firm. The alternative is to decentralize this choice to unit managers. As noted above, centralization (common ownership) is preferred when choosing less synergistic assets is important.

Finally, our model suggests that sometimes the most obvious takeover or merger targets are not the best. There have been some spectacular M&A failures - for example AT&T/NCR, Quaker Oats/Snapple, Daimler/Chrysler and AOL/Time Warner. In all these cases the participants expected significant synergies that did not eventuate. The failure of M&As is conventionally attributed to cultural differences between the two firms or a failure to conduct proper due diligence. While these factors are undoubtedly important, they do not explain the observation that 'the acquiring firms in 'related' mergers do not benefit or are actually worse off compared to unrelated as well as horizontal mergers' (Chatterjee 2007). Our model suggests that – just like high-synergy incumbents being paired together – it is exactly the mergers that seem to have the largest synergy between the assets can create a (relative) disincentive to invest, leading to lower surplus overall.

Appendix

Derivation of the surplus shares for the principal and agent

Let us derive the ex ante payoffs given by the Shapley value for each team member and the Principal with the help of equation (2). The payoffs of coalitions are as follows: $v(P, A_1, A_2) = v_{12}$, $v(P, A_1) = v_1$ and $v(P, A_2) = v_2$, while all other coalitions give zero payoffs. Consequently,

$$B_1 = \frac{1}{6}v_1 + \frac{1}{3}(v_{12} - v_2) = \frac{1}{2}v_1 + \frac{1}{3}S, \tag{31}$$

$$B_2 = \frac{1}{6}v_2 + \frac{1}{3}(v_{12} - v_1) = \frac{1}{2}v_2 + \frac{1}{3}S, \tag{32}$$

and

$$B_P = \frac{1}{6}v_1 + \frac{1}{6}v_2 + \frac{1}{3}v_{12} = \frac{1}{2}v_1 + \frac{1}{2}v_2 + \frac{1}{3}S. \tag{33}$$

This concludes the derivation. $\square$

Proof of Proposition 2

First, from equation (8) if $v_1^I + v_2^I - v_1^C - v_2^C < \frac{2}{3}(S_1^I - S_0^N)$, the principal will choose two incumbent agents. Second, from equation (20), when $v_1^I + v_2^I - v_1^C - v_2^C < S_1^I - S_0^N + \Delta C_1(e_1) + \Delta C_2(e_2)$ it is efficient to choose incumbents. The difference between the right-hand side of these two equations is $\frac{1}{3}(S_1^I - S_0^N) + \Delta C_1(e_1) + \Delta C_2(e_2) > 0$. Consequently, if equation (8) is satisfied, equation (20) is satisfied as well. This proves the proposition. $\square$

Proof of Proposition 3

With incumbents, the equilibrium levels of investment solve the following first-order conditions:

$$\frac{1}{2}v_i'(e_i) + \frac{1}{3}\frac{\partial S_1(e_1, e_2)}{\partial e_i} = \frac{\partial C_i(e_i)}{\partial e_i}, \ \ \forall \ i = 1, 2. \tag{5}$$

With newcomers, the equilibrium levels of investment solve the following first-order conditions:

$$\frac{1}{2}v_i'(e_i) + \frac{1}{3}\frac{\partial S_0(e_1, e_2)}{\partial e_i} = \frac{\partial C_i(e_i)}{\partial e_i}, \ \forall \ i = 1, 2. \tag{6}$$

As $\frac{\partial S_1(e_1,e_2)}{\partial e_i} \geq \frac{\partial S_0(e_1,e_2)}{\partial e_i}$, relative investment incentives are higher for incumbents. Moreover, surplus must be higher because not only do incumbents enjoy a larger synergy but they also put in more effort than newcomers. See Mai et al (2013) for an equivalent proof. □

References

[1] Alchain, A. and Demsetz, H. 1972, 'Production, Information Costs, and Economic Organization', *American Economic Review*, 62 (December): 777-795.

[2] Arya, A., and Mittendorf, B. (2004), 'Using return polices to elicit retailer information,' *RAND Journal of Economics*, 35(3), 617-630.

[3] Azizi, Nader and Zolfaghari, Saeed and Liang, Ming (2010), 'Modeling job rotation in manufacturing systems: The study of employees boredom and skill variations', *International Journal of Production Economics*, 123, 69-85.

[4] Bel, R. (2012), 'Access, veto, and ownership in the theory of the firm', *Journal of Law, Economics and Organization*, doi: 10.1093/jleo/ews003.

[5] Bernstein, S., and Winter, E. (2012), 'Contracting with heterogeneous externalities', *American Economic Journal: Microeconomics*, 4(2): 50-76.

[6] Brickley, J., Smith, C. and J. Zimmerman (2009), *Managerial Economics and Organizational Architecture*, 5th edition, McGraw-Hill, New York.

[7] Chatterjee, S. (2007), 'Why is synergy so difficult in mergers of related businesses?', *Strategy and Leadership*, 35(2), 46-52.

[8] Che, Yeon-Koo and Yoo, Seung-Weon (2001), 'Optimal Incentives for Teams', *American Economic Review*, 91(3), 525-541.

[9] Choi, J. P., and Thum M. (2003), 'The dynamics of corruption with the ratchet effect,' *Journal of Public Economics*, 87(3-4), 427-443.

[10] Corts, K. (2006), 'The interaction of task and asset allocation', *International Journal of Industrial Organization*, 24, 887-906.

[11] Franco, A., Mitchell, M. and Vereshchagina (2011), 'Incentives and the Structure of Teams', *Journal of Economic Theory*, 146, 23072332.

[12] Guimera, Roger, Brian Uzzi, Jarrett Spiro, and Luis A. Nunes Amaral, (2005), 'Team assembly mechanisms determine collaboration network structure and team performance', *Science*, 308, 697-702.

[13] Hart, O. (1995), *Firms, contracts, and financial structure*, Oxford University Press, London.

[14] Hart, O. and Moore J. (1990), 'Property rights and the theory of the firm', *Journal of Political Economy*, 98(6), 1119-1158.

[15] Holmstrom, B. (1982), 'Moral hazard in teams', *Bell Journal of Economics*, 13(2), 324-40.

[16] Holmstrom, Bengt and Paul Milgrom (1991), 'Multi-task principal-agent analyses: linear contracts, asset ownership and job design', *Journal of Law, Economics and Organization*, 7, 24-52.

[17] Ingham, A.G., Levinger, G., Graves, J., and Peckham, V. (1974), 'The Ringelmann effect: studies of group size and group performance', *Journal of Experimental Social Psychology*, 10, 371384.

[18] Jeon, S. (1996), 'Moral Hazard and Reputational Concerns in Teams: Implications for Organizational Choice', *International Journal of Industrial Organization*, 14, 297-315.

[19] Kaya, A. and Vereshchagina, G. (2010), 'Moral Harard and Sorting in a Market for Partnerships', mimeo.

[20] Klor, E., Kube, S., Winter, E., and Zultan, R. (2012), 'Can higher bonuses lead to less effort? Incentive reversal in teams', IZA Discussion Paper No. 5501.

[21] Kravitz, D. and Martin, B. (1986), 'Ringelmann rediscovered: the original article', *Journal of Personality and Social Psychology*, 50(5), 936-941.

[22] Mai, M, Smirnov, V. and Wait, A. (2013), 'Ownership, access and sequential investment', *Canadian Journal of Economics*, forthcoming.

[23] Milgrom, P. and Roberts, J. (1990), 'The efficiency of equity in organizational decision processes,' *American Economic Review*, 80(2), 154-59.

[24] Newman, A. (2007), 'Risk-bearing and Entrepreneurship', *American Economic Review*, 137, 11-26.

[25] Osborne, M. and Rubinstein, A. (1994), *A course in game theory*, Cambridge, Massachusetts: MIT Press.

[26] Segal, I. (1999), 'Contracting with Externalities', *Quarterly Journal of Economics*, 114, 337-388.

[27] Segal, I. (2003), 'Coordination and Discrimination in Contracting with Externali- ties: Divide and Conquer?', *Journal of Economic Theory*, 113, 147-327.

[28] Shaw, M. (1932), 'A comparison of individuals and small groups in the rational solultion of complex problems', *American Journal of Psychology*, 44, 491-504.

[29] Stroebe, W., Diehl, M. and Abakoumkin, G. (1996), 'Social compensation and the Kohler effect: Towards an Explanation of Motivation Gains in Group Productivity', (pp. 37-65), in E.H. Witte and J.H. Davis (eds), *Understanding group behavior, Vol. 2 Small group processes and interpersonal relations*, Lawrence Erlbaum, Mahwah, N.J.

[30] Thiele, H and Wambach, A. (1999), 'Wealth Effects in the Principal Agent Model', *Journal of Economic Theory*, 89, 247-260.

[31] West, M. (2004), *Effective teamwork: practical lessons from organizational research*, 2nd Edition, Blackwell, Oxford.

[32] Uzzi, Brian and Spiro, J. (2005), 'Collaboration and creativity: the small world problem', *American Journal of Sociology*, 111(2), 447-504.

[33] Winter, E. (2004), 'Incentives and Discrimination', *American Economic Review*, 94, 764-773.

[34] Winter, E. (2006), 'Optimal Incentives for Sequential Production Processes', *Rand Journal of Economics*, 37(2), 376-390.

[35] Winter, E. (2009), 'Incentive reversal', *American Economic Journal: Microeconomics*, 1(2): 133-47.

[36] Winter, E. (2012), 'Transparency among Peers and Incentives', *Rand Journal of Economics*, forthcoming.