Turf Wars

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Abstract

Turf wars in organizations commonly occur in environments where competition undermines collaboration. We develop a game theoretic model and experimental test of turf wars. The model explores how team production incentives *ex post* affect team formation decisions *ex ante*. In the game, one agent decides whether to share jurisdiction over a project with other agents. Agents with jurisdiction decide whether to exert effort and receive a reward based on their relative performance. Hence, sharing can increase joint production but introduces competition for the reward. We find that collaboration has a non-monotonic relationship with both productivity and rewards. The laboratory experiment confirms the model's main predictions.

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1 Introduction

The “turf war” is one the most commonly recognized organizational pathologies.[1] When informally discussing turf wars with people with work experience, anecdotal accounts abound. While there is no consensus on the definition of the term, accounts of the phenomenon typically possess common elements. Agents, such as government bureau heads or corporate division managers, perceive themselves to be in competition with one another over resources, promotions, or publicity.[2] This friction hampers efficient, that is welfare maximizing, team formation: given the opportunity to pursue an important task or assignment, these agents will attempt to exclude rivals from participation. Tactics might include withholding crucial information, or using decision-making rights to shunt rivals’ activities into low-profile tasks. Importantly, principals or other external actors may want agents to collaborate, but they do not always have the ability to enforce such behavior.

Unsurprisingly, turf battles are widely believed to have significant adverse effects on organizational performance. In his classic analysis of bureaucratic politics, Wilson (2000) devoted an entire chapter to describing the consequences of turf-motivated strategies. Moreover, examples involving some of the largest organizations and most significant pieces of legislation are not difficult to find. The following list illustrates four major instances of turf wars. All suggest persistent inefficient allocations of property rights that were ultimately addressed through external interventions.

U.S. Military Branches. The National Security Act of 1947 established the basic structure of the modern U.S. national security bureaucracy. The law preserved the relative autonomy of the individual armed services, which led to competition and low levels of coordination between functionally similar units. In the Korean and Vietnam wars, the Navy and Air Force ran essentially independent air campaigns, and subsequent operations in Lebanon and Grenada in the early 1980s were marred by the services’ inability to communicate. As Lederman (1999) documents, this performance record culminated in the 1986 Goldwater-Nichols Act. The reforms included the creation of Unified Combat Commands, which allowed local commanders to coordinate centrally the activities of all American forces operating in a given region.

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[1] We look at organizational behavior, but the term “turf wars” can be used to refer to other research domains such as conflict and politics. This is not what we address here.

[2] An alternative view, offered by Garicano and Posner (2005), is that turf wars are a form of influence activities (Milgrom and Roberts 1988).

Emergency Management in New York City. The events of September 11, 2001 revealed widespread deficiencies in the ability of the city's agencies to share jurisdiction over emergency responses. The police and fire departments' activities on that day were often wastefully redundant, and the lack of interoperable radio equipment hampered even attempts at cooperation (see Hauser 2008). These shortcomings resulted in the 2004 introduction of the Citywide Incident Management System, which attempted to identify more clearly a lead agency for specific types of emergency events. As Esposito (2011) documents, this system has generated a new set of turf battles. For example, the police department could exclude the fire department by designating a site as a "crime scene", or it could fail to share information that would maximize the fire department's resources.

Pepsico's restaurants. While it was the owner of Pizza Hut, Taco Bell, and KFC, Pepsico operated the restaurant chains as autonomous divisions that competed with each other and reported directly to the CEO (Dahlstrom et al. 2004). As a result, managers worked independently and rarely communicated with each other because they feared they would give away trade secrets. The restaurant chains often failed to coordinate their purchasing, headquarter tasks, data management, and real estate functions, effectively relinquishing an estimated $100 million per year in cost savings (Montgomery 2001). Some of these issues were subsequently addressed when the restaurant chains were spun off to form Tricon Global Restaurants, which allowed the creation of common procurement and information management divisions (Dahlstrom et al. 2004).

Drug Enforcement. Wilson (1978) discusses the U.S. Drug Enforcement Agency's (DEA) geographical drug enforcement program, which was used to allocate "buy money" for drug investigations. The money was allocated competitively across DEA regions on the basis of previous arrests, with more significant arrests earning larger rewards. This, however, resulted in perverse sharing incentives:

> "Many drug distribution networks cut across regional lines. One organization may bring brown heroin from Mexico in to Detroit, where it is cut and then sent on to Boston or New York to be sold on the street. Six DEA regions have an interest in this case ... If agent and regional directors believe they are rewarded for their stats, they will have an incentive to keep leads and informants to themselves in order to take credit for a Mexican heroin case should it develop. A more appropriate strategy would be for such information to be shared so that an interregional case can be made ... The perceived evaluation and reward system of the organization ... threatens to lessen the credit, and therefore (it is believed) the resources, available for a given region."

The geographical drug enforcement program induced a bias toward capturing street-level offenders, even though most agents and outsiders would have preferred higher profile cases.[3] The DEA responded to these sharing issues by creating investigation-specific inter-regional task forces. However, these task forces often only displaced the turf issue, as regional offices were reluctant to share their best agents and the assignment of credit for a successful investigation could be difficult.

These examples illustrate that there exist many instances in which cooperation among competing agencies is hard to achieve, in spite of repeated interactions, and where *ex ante* transfers that implement the efficient, welfare maximizing, allocation of resources are unavailable.[4]

This paper develops a model of organizational turf wars. It is, to our knowledge, the first model to consider how turf wars in organizations arise, and how they might be controlled. As Posner (2005) notes, "The literature on turf wars is surprisingly limited, given their frequency and importance" (p. 143). Accordingly, the model is simple and attempts to capture only the essential elements of a turf battle. We view these elements to be the following.

Joint production. Perhaps most obviously, questions about responsibility over a task can only arise between agents who are capable of contributing to the joint production of relevant outcomes.

Property rights. Agents have property rights over their jurisdiction. In other words, agents can choose whether they want to involve other agents in the production process they control or exclude them to protect their turf.[5]

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[3] Wilson (1978) mentions variations of this behavior at several levels in the investigation and prosecution of drug law violators: e.g., by U.S. Attorneys, local police agencies, and the Federal Bureau of Investigation.

[4] Even within academia, activities such as co-authorships have a similar incentive structure to the DEA example above. When deciding whether to invite a second author into a promising new research idea or project, the first author faces a clear trade-off. While co-authorship with a more skilled second author is likely to increase significantly the quality of an article, it is also likely to lessen the individual credit and perhaps the promotion chances of the first author. This problem is most prominent in disciplines where the formation of research teams is a first order problem, such as medicine and biology.

[5] An important assumption of our model is that an external actor such as a legislature cannot simply force agents to share jurisdiction, which trivializes the problem. The motivating logic behind centralizing re-organizations such as those proposed by the *9/11 Commission Report* is that agents would be more easily induced to share if they were placed under one roof. While this approach has no doubt had its successes, such reforms have not been uniformly successful. One reason for this is that competition may be more pronounced within organizations than between them (e.g., Posner 2005). In the U.S. Central

Competition. Agents must be in competition. The competition might be over an explicit prize, for example a promotion in a rank-order tournament, or an informal reward. The intensity of the competition might emerge from basic indivisibilities of prizes that are only awardable to a single "winner." Examples include gaining favorable media attention, or securing a prestigious project assignment.[6]

Our basic model considers two agents who can exert effort in order to contribute to a collective project. One agent, labeled the *originator*, begins the game by choosing the set of agents who will have jurisdiction over the project.[7] She may keep jurisdiction, which prevents the partner agent from working, she may refer jurisdiction, thus giving the partner exclusive authority, or she may share jurisdiction, allowing both agents to work on the project. Agents care about the project's overall output and an indivisible prize that is increasing in their joint production. Each agent's productivity is common knowledge, and the probability of winning the prize is increasing in each agent's relative contribution to the project. Sharing jurisdiction increases the project's overall output but reduces the originator's probability of receiving the prize. A turf war then occurs when the originator keeps jurisdiction when sharing would have been socially desirable.

We model the "turf war" as fundamentally asymmetric because it is the simplest way to capture the clash of preferences over property rights: the second agent may wish to have jurisdiction, while the first agent (the originator) may work to deny it. This sharing/withholding decision is, *in that moment*, a one-sided decision by the originator that may result in a loss of total welfare. More generally, one can envision that at some time in the future, the second agent becomes the originator (i.e., receives independent information relevant to the work of the first agent), and so forth in alternation for future periods. The one-shot asymmetric game equilibrium described here remains an outcome of this more complex repeated interaction.[8] Hence, despite its simplicity, our basic setup

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Intelligence Agency, for example, the two main branches (operations and analytics) are historically fierce rivals (Gates 1987). Thus, we focus on the determinants of turf wars in environments where collaboration is plausibly non-contractible.

[6] This assumption is considered natural in the bureaucratic setting. For example, Downs (1966) argued that bureaucracies were in a constant state of competition, and in particular that "No bureau can survive unless it is continually able to demonstrate that its services are worthwhile to some group with influence over sufficient resources to keep it alive."

[7] Originator status may arise from technology or statutory assignments of responsibility, or from a principal's inability to re-assign property rights.

[8] For some range of parameters additional outcomes may be sustainable in the repeated game.

is sufficient to obtain our core results.[9]

The most important predictions of the model concern the conditions that generate collaboration (i.e., the outcome where the originator shares and both agents work). As intuition would suggest, agents work when their productivity and the size of the prize are sufficiently high. Moreover, when both agents have the opportunity to work, they have a higher incentive to free-ride. The incentives to share their jurisdiction are more complex. Increasing the prize has two main effects. At low levels, it increases the originator's incentive to share through the inducement of work by the partner. However, at very high levels, it can reduce her incentive to share and induce a turf war. Thus, collaboration benefits from increasing the competitive prize in some instances and decreasing it in others. Somewhat surprisingly, the effect of increasing originator productivity can be non-monotonic. This occurs because both the least and most productive originators always share when the partner is willing to work, but intermediate types may not.[10] In some cases, increasing the originator's productivity from a low level can actually reduce overall output.

We test the predictions of the model with a laboratory experiment. This exercise is especially relevant for our topic because turf wars are difficult to observe directly in the field.[11] In particular, lack of sharing and collaboration are hard to observe and the incentives to do so are hard to quantify. The experiment focuses on some of the more interesting implications of our model, especially the potential non-monotonic effect of the competitive prize on sharing and joint production. Even though in the laboratory experiment we implement the specific incentive structure assumed in the model, an empirical test is by no means trivial. It is well-known that not all individuals behave as if they are maximizing their own (monetary) payoff. Over the past few decades, there has been considerable progress in understanding how individuals deviate from these standard assumptions and how the interaction of payoff-maximizing individuals with these "behavioral" types affect

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[9] In the appendix, we also develop several extensions to the basic model in order to explore the robustness of its results. Specifically, we introduce production synergies, asymmetric information, multiple agents, and continuous effort. In these extensions, the model's main insights persist. In particular, we see a "turf war" emerging when the originator's productivity is moderate and the competitive pressure is high.

[10] Generally, the most productive originators share and work while the least productive ones tend to share and shirk. We also find that if agents are motivated more by joint output than by the prize of winning, a subset of originators with relatively low productivity will also share and work.

[11] The most salient empirical analyses of turf wars study how political institutions acquire new responsibilities. King (1994, 1997) analyze the evolution of the division of labor across U.S. Congressional committees (see also Bannister 2005). Consistent with our model, Wilson (2000) argues that bureaucracies' preferences over new jurisdiction are shaped in large part by their competitive environment.

economic outcomes (see Dhami 2016). Despite this progress, it is still unclear in which specific contexts such deviations result in qualitative departures from standard equilibrium predictions (for a discussion see, Camerer and Fehr 2006). Hence, running an experiment serves two purposes. First, it allows us to test whether predictions derived from standard assumptions fare well in a turf war context. Second, by analyzing any departures from these predictions, it allows us to generate additional insights that could lead to improved theoretical analyses.

Our results provide strong support for the qualitative predictions of the model. We find that increasing the prize initially increases production as it provides an incentive to both agents to exert effort. Further increases, however, clearly result in suboptimal jurisdiction decisions and a considerable reduction in joint production when the originator is of intermediate productivity.

While there are no other formal models and only a few empirical attempts that explicitly address the idea of turf wars in organizations,[12] this paper is related to work on tournaments, sabotage, information sharing, and referrals.

The fact that agents who share jurisdiction compete for an indivisible prize that is awarded according to relative performance implies that our model is related to the literature on rank-order tournaments (Lazear and Rosen 1981).[13] This line of research describes the relationship between effort and competition among individuals (e.g., Schotter and Weigelt 1992; Bull et al. 1987) as well as among groups (e.g., Nalbantian and Schotter 1997; Tan and Bolle 2007; Markussen et al. 2014).[14] We contribute to this literature by adding an initial sharing stage in which the originator effectively decides whether she

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[12] A 2016 JSTOR article search of the term "turf war" in economics, political science, and management yields 7 title hits and 8 abstract hits, none of which are associated with a formal model of organizations. In economics, research on turf wars focuses on the areas of political economy and conflict (see e.g., Burrus 1999; Filson and Werner 2002; Chowdhury et al. 2016; Chowdhury and Topolyan 2016).

[13] For recent reviews of the theoretical and experimental literatures see Connelly et al. (2014) and Sheremeta (2015), respectively.

[14] There is also a large literature on rent-seeking contests based on the model of Tullock (1980), which models the exertion of effort in order to win a fixed prize as wasteful (for a review of this literature see Congleton et al. 2008; Dechenaux et al. 2015). Especially relevant within this literature is Muller and Warneryd (2001), who uses a variation of the contest model to capture conflict inside partnerships and the conditions under which loses due to internal conflict make outside ownership more desirable. Also related are the papers studying how rules governing the allocation of profits, within a group, which determine the degree of internal conflict, affect the incentives of group members to exert effort when competing with other groups for external resources (see e.g., Katz et al. 1990; Katz and Tokatlidu 1996; Davis and Reilly 1999; Nitzan 2001; Ke et al. 2013).

wants to compete in a tournament with the partner agent. This allows us to study the conditions under which tournaments that would otherwise increase effort result instead in lack of sharing between agents and low output.

A subset of the literature on rank-order tournaments that is important in relation to our model is that of sabotage (e.g., Lazear 1989; Konrad 2000; Chen 2003; Falk et al. 2008; Harbring and Irlenbusch 2005, 2011; Balafoutas et al. 2012).[15] Although we do not model it here, sabotage might be one way in which turf battles are fought, especially when agents are brought together involuntarily. These models focus on inefficiencies that arise because competition gives agents in a given team an incentive to sabotage each other's output. By contrast, in our model, competition can result in inefficiencies due to jurisdictional tools available to the originator that allow her to choose the composition of the team. A distinctive feature of our model compared to the literature on sabotage is that because of the benefits of joint production, more intense competition does not necessarily lead to welfare losses.

A second related literature is that on information sharing. Like sabotage, the failure to reveal information relevant to collective outcomes might be considered a failure of collaboration. A central question in this work is the extent to which players reveal their private information, even when they are in competition. Okuno-Fujiwara et al. (1990) develop a two-stage model in which players first decide non-cooperatively whether to make a verifiable report of their information, and derive conditions for full revelation.[16] Other models have developed this idea in more specific strategic contexts. Stein (2008) models two competitors who have complementary ideas in alternating periods. Each player is willing to reveal her idea to the competitor if she uses it to form a better idea that will be passed back in turn. High levels of complementarity and skill sustain information sharing in equilibrium.

Finally, our model is related to those of Garicano and Santos (2004) and Herbst et al. (2015). Garicano and Santos (2004) study the market for referrals of tasks between agents under incomplete information (see also, Landini et al. 2013). Like us, they model a situa-

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[15] For a recent survey on sabotage see Chowdhury and Gürtler (2015).

[16] A few papers on information sharing in oligopoly competition also consider the question of whether competitors share information in settings where they can commit to doing so prior to its revelation (e.g., Gal-Or 1985; Creane 1995; Raith 1996). See also Modica (2010), who shows how competing firms might contribute to open source projects, and Baccara and Razin (2007), who develop a bargaining model in which innovators share ideas in order to develop them but worry that by doing so their ideas could be stolen.

tion where inefficiencies arise due to agents failing to share jurisdiction over tasks. However, their paper focuses on institutional solutions to matching problems, rather than on the possibilities for joint production. Herbst et al. (2015) study a situation where players of varying productivity, which they model as different costs, are willing to form a team in order to compete with a third party. This is similar to sharing jurisdiction in our setting, but they do not analyze the effect of subsequent competition within teams.

2 The model

In this section, we describe the game theoretic model and the main theoretical results. This core setup resembles that of Garicano and Santos (2004) but crucially also features collaboration (or lack thereof) between agents on a single project, which is the central focus of our analysis.

The model analyzes the decision to protect one's turf, or the decision of a first agent to possibly withhold some capability or information that is payoff relevant for the work of a second agent. This sharing/withholding decision is a one-sided decision. Arguably, it is more natural to think of a context with several agents where each agent possibly receives, at independent Poisson times, information relevant to one or more other agents. At that point, agents would decide whether to withhold this information or to share it. In this symmetric repeated interaction more cooperative equilibria may be sustainable for a certain range of parameter values. However, it should be noted that the equilibrium of the one-shot asymmetric game we derive here remains an equilibrium of the more realistic symmetric repeated interaction.

There are two agents, labeled A1 and A2. One agent (without loss of generality, A1) has initial jurisdiction over a task. We label A1 the *originator*. The originator's key decision is to what extent to share jurisdiction with A2.

Each agent i generates an output level $x_i \in \{0, \theta_i\}$ for the task when she has jurisdiction over it. When Ai does not have jurisdiction, her output is $x_i = 0$. The parameter $\theta_i \in [0, 1]$ represents i's productivity and is common knowledge. Ai's output level is given simply by $e_i\theta_i$, where $e_i \in \{0, 1\}$ is i's effort level.[17] We assume that the effort cost of agent Ai is $e_i k$. We denote by $x = x_1 + x_2$ the total output of the agents.

Agents receive utility from two sources. First, they value aggregate output, with

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[17] We develop an extension using continuous effort in the appendix. While the setup of this extension is simple, the equilibrium conditions are cumbersome and hard to characterize. However, simulations suggest that the insights from the discrete effort model remain.

Ai receiving mx, where $m > 0$. This represents a kind of "policy" motivation or the share received by an agent according to a revenue-sharing incentive scheme. Second, they compete for a prize of value βx, where $\beta > 0$. We impose $k \in (0, m + \beta)$: this upper bound on k ensures that exerting effort is undominated. The prize might represent a form of credit for superior performance, such as a promotion, a bonus, or public recognition. When only Ai has jurisdiction, she wins the prize with certainty. When both agents have jurisdiction, the probability of victory depends on relative outputs and a random noise term. A1 then wins when $x_1 > x_2 + \varepsilon$, where $\varepsilon \sim U[-1, 1]$. Hence, A$i$'s probability of victory is easily calculated as:[18]

$$\omega_i(x_i, x_{-i}) = \frac{x_i - x_{-i} + 1}{2}. \tag{1}$$

Putting all of the elements together, Ai receives the following expected utility:

$$u_i = \begin{cases} m\,(x_1 + x_2) + \beta\,(x_1 + x_2)\,\omega_i - e_i k & \text{if both have jurisdiction} \\ m x_i + \beta x_i - e_i k & \text{if only A}i\text{ has jurisdiction} \\ m x_{-i} & \text{if only A}{-i}\text{ has jurisdiction.} \end{cases} \tag{2}$$

The game begins with A1 choosing $s \in \{\text{share}, \text{keep}, \text{refer}\}$. Under "share", both agents have jurisdiction. Under "keep", only A1 has jurisdiction, while under "refer", A1 passes jurisdiction to A2. After the assignment of jurisdiction, the agents with jurisdiction choose effort $e_i \in \{0, 1\}$.[19] This choice is simultaneous when both agents have jurisdiction. We derive the subgame perfect equilibrium.

2.1 Equilibrium

We begin with the agents' effort choices. Consider first the subgame following A1's choice to share. The best responses are easy to derive. Ai works, i.e. exerts effort, when her partner works if

$$m(\theta_1 + \theta_2) + \beta(\theta_1 + \theta_2)\,\omega_i(\theta_i, \theta_{-i}) - k \geq m\theta_{-i} + \beta\theta_{-i}\,\omega_i(0, \theta_{-i}). \tag{3}$$

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[18] We follow the convention in the rank-order tournament literature and determine the winner using differences in output and random noise, which can be interpreted as the result of output not being perfectly observable (Lazear and Rosen 1981). An alternative would be to follow the rent-seeking literature and use a contest success function based on relative output differences: $\omega_i(x_i, x_{-i}) = \frac{x_i^d}{x_i^d + x_{-i}^d}$. The rent-seeking approach is equivalent to a rank-order tournament if production functions are linear and noise is exponentially distributed (Loury 1979).

[19] Our model does not feature the possibility of declining jurisdiction. More precisely, we do not distinguish A2's decision of declining jurisdiction from accepting jurisdiction and not working. If declining is interpreted as having zero chance of winning the prize, then it is dominated by accepting jurisdiction and shirking, which entails a positive chance of winning the prize β.

She works when her partner does not work if

$$m\theta_i + \beta\theta_i\,\omega_i(\theta_i, 0) - k \geq 0. \tag{4}$$

Both expressions result in the same threshold:

$$\theta_i \geq \theta^H \equiv \frac{-\left(m + \frac{\beta}{2}\right) + \sqrt{\left(m + \frac{\beta}{2}\right)^2 + 2\beta k}}{\beta}. \tag{5}$$

This threshold is strictly positive and decreasing in m. Thus, Ai has a weakly dominant strategy to work when $\theta_i \geq \theta^H$. Note that with a non-uniform distribution, agents may not have a dominant strategy, but the incentive to work would still be increasing in θ_i.

Next, consider the subgame in which only one agent has jurisdiction. This happens to A2 when A1 refers, as well as to A1 when she keeps jurisdiction. Ai works when alone if:

$$\begin{aligned} (m+\beta)\theta_i - k &> 0 \qquad (6) \\ \theta_i &\geq \theta^L \equiv \frac{k}{m+\beta}. \qquad (7) \end{aligned}$$

The following lemma establishes the relationship between the two thresholds. We provide all the paper's proofs in the appendix.

Lemma 1 *Second stage effort thresholds.*

$$\begin{aligned} k = 0 &\iff \theta^L = \theta^H = 0 \\ k \in (0, m+\beta) &\iff 0 < \theta^L < \theta^H < 1 \\ k = m+\beta &\iff \theta^L = \theta^H = 1. \end{aligned}$$

Thus we have three disjoint regions that characterize effort as a function of productivity. The least able agents, with productivity $\theta_i \in (0, \theta^L)$, always choose $e_i^* = 0$. The most able agents, with productivity $\theta_i \in (\theta^H, 1)$, always choose $e_i^* = 1$. Finally, agents with intermediate productivity $\theta_i \in (\theta^L, \theta^H)$ choose $e_i^* = 1$ only if they alone have jurisdiction, otherwise they choose $e_i^* = 0$. As intuition would suggest, each agent's incentive to work is increasing in her productivity. She is also more inclined to work when she has sole jurisdiction as opposed to shared jurisdiction, since the latter entails a positive probability of losing β even when the partner exerts no effort.

Moving to the first stage sharing choice, it is convenient to use the labels listed in Table 1 to refer to the different jurisdiction-effort profiles in the game. Observe that A1 would never share if A2 would not work, and so we ignore this combination. In addition, the outcome where A1 keeps jurisdiction and exerts effort is labeled as *autarchy* if it is efficient in terms of total welfare and as a *turf war* if it is inefficient.

Table 1. Jurisdiction-effort profiles

Label	Case	Jurisdiction	Effort
Indifference	*i*	any	none
Autarchy/Turf war	*i, ii, iii*	A1	A1
Referral	*ii*	A2	A2
Delegation	*iii*	A1, A2	A2
Collaboration	*iii*	A1, A2	A1, A2

There are three cases corresponding to the region containing θ_2. These cases are labeled with Roman numerals in Table 1. First, when $\theta_2 \in (0, \theta^L)$, A1 anticipates no effort from A2. A1's decision then depends only on whether she herself will work. If $\theta_1 < \theta^L$, the result is indifference, while if $\theta_1 > \theta^L$, A1 does strictly better by keeping and the result is autarchy.

Second, when $\theta_2 \in (\theta^L, \theta^H)$, sharing results in no effort by A2. Thus, A1 keeps if she prefers to work and refers if she prefers that A2 works alone. A1 prefers keep to refer if:

$$\theta_1 \quad > \quad \frac{m\theta_2 + k}{m + \beta}. \tag{8}$$

As with the case for $\theta_2 \in (0, \theta^L)$, higher values of θ_1 are associated with autarchy. But now with a stronger A2, a weaker A1 has a strict preference for a referral. The threshold in (8) is obviously strictly greater than θ^L, since an originator who never works would clearly prefer referral to autarchy. This implies that the range of θ_1 values that generate autarchy is strictly smaller as A2 moves from low to moderate productivity.

The third and most complex case is when $\theta_2 > \theta^H$. The experiment in Section 3 focuses on this case. It is clear that indifference and referrals are not possible in this setting: since A2 is guaranteed to work, A1 prefers delegation, or sharing without working, to these outcomes because it provides a positive probability of victory. Hence, A1's choice boils down to a decision over delegation, collaboration, and turf war. Collaboration increases productivity but at the expense of A1's effort; by the definition of θ^H, the originator will prefer this to delegation if $\theta_1 > \theta^H$. Withholding jurisdiction from A2 increases the chances of victory but is inefficient in terms of total welfare.

To determine whether A1 will choose keep or share, it will be useful to introduce three new parameters that give the values of θ_1 at which A1 is indifferent. First, suppose $\theta_1 > \theta^H$, so that both agents will work if they have jurisdiction. Comparing the left-hand sides of (3) and (6), A1 is indifferent between collaboration and turf war when:

$$\theta^{\pm} \equiv \frac{1}{2} \pm \sqrt{\frac{1}{4} - \theta_2 \left(\frac{2m}{\beta} + 1 - \theta_2 \right)} \tag{9}$$

When θ^+ and θ^- are not real-valued, A1 prefers collaboration to autarchy, and thus shares. Next, suppose $\theta_1 \in (\theta^L, \theta^H)$, so that A1 is in effect choosing who will work. Comparing the left-hand sides of (4) and (6), A1 is indifferent between delegation and autarchy at the following value of θ_1:

$$\tilde{\theta} \equiv \frac{m\theta_2 + \frac{1}{2}\beta\theta_2\left(1-\theta_2\right) + k}{m+\beta}. \tag{10}$$

The next result summarizes outcomes for all combinations of θ_1 and θ_2. The main finding comes from the third case: when $\theta_2 > \theta^H$ a turf war can occur for "moderate" values of θ_1 between $\max\{\theta^H, \theta^-\}$ and θ^+. Moderate ability originators will generate inefficiencies because sharing would greatly reduce their chances of receiving the prize to a high-ability partner. By contrast, low productivity originators share (resulting in delegation or collaboration) despite the likely loss of the prize because they would not be able to produce a valuable-enough project alone. Finally, high productivity originators share because they have a high probability of winning the prize, and the result is collaboration.

Proposition 1 (Outcomes)

(i) If $\theta_2 \in (0, \theta^L)$ then

$$\begin{cases} \textit{indifference} & \textit{if } \theta_1 < \theta^L \\ \textit{autarchy} & \textit{if } \theta_1 > \theta^L. \end{cases}$$

(ii) If $\theta_2 \in (\theta^L, \theta^H)$ then

$$\begin{cases} \textit{referral} & \textit{if } \theta_1 < \frac{m\theta_2+k}{m+\beta} \\ \textit{autarchy} & \textit{if } \theta_1 > \frac{m\theta_2+k}{m+\beta}. \end{cases}$$

(iii) If $\theta_2 \in (\theta^H, 1)$ and $\theta^H < \tilde{\theta}$ then

when θ^- and θ^+ are not real-valued or $\theta^+ < \theta^H$

$$\begin{cases} \textit{delegation} & \textit{if } \theta_1 \in (0, \theta^H) \\ \textit{collaboration} & \textit{if } \theta_1 \in (\theta^H, 1), \end{cases}$$

and when θ^- and θ^+ are real-valued and $\theta^+ > \theta^H$

$$\begin{cases} \textit{delegation} & \textit{if } \theta_1 \in (0, \theta^H) \\ \textit{collaboration} & \textit{if } \theta_1 \in (\theta^H, \theta^-) \\ \textit{turf war} & \textit{if } \theta_1 \in (\max\{\theta^H, \theta^-\}, \theta^+) \\ \textit{collaboration} & \textit{if } \theta_1 \in (\theta^+, 1), \end{cases}$$

where (θ^H, θ^-) is possibly empty.

Else if $\theta_2 \in (\theta^H, 1)$ and $\theta^H > \tilde{\theta}$ then

$$\begin{cases} \textit{delegation} & \textit{if } \theta_1 \in (0, \tilde{\theta}) \\ \textit{turf war} & \textit{if } \theta_1 \in (\tilde{\theta}, \max\{\theta^H, \theta^+\}) \\ \textit{collaboration} & \textit{if } \theta_1 \in (\max\{\theta^H, \theta^+\}, 1). \end{cases}$$

For high values of θ_2, there are three possible patterns of outcomes as θ_1 increases from 0 to 1: delegation → collaboration, delegation → turf war → collaboration, and delegation → collaboration → turf war → collaboration. The final pattern may appear

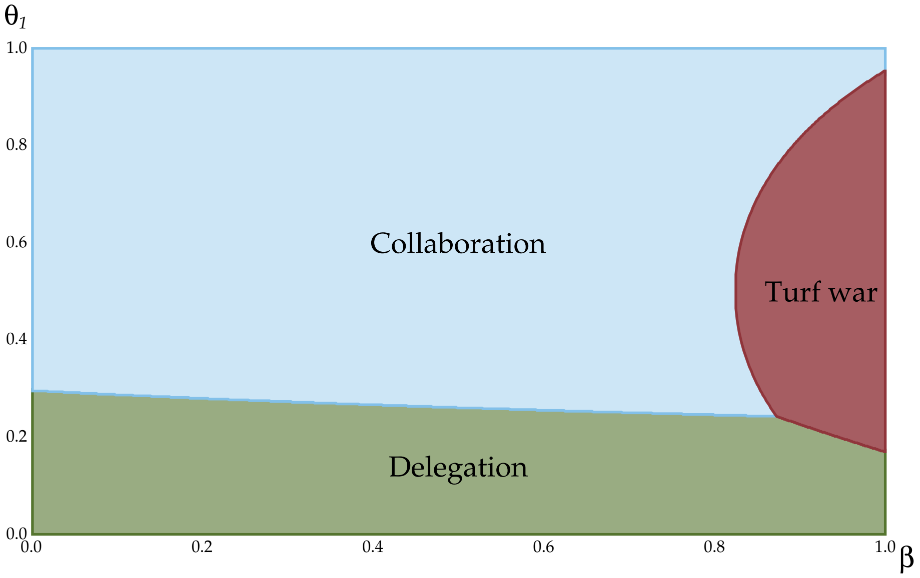

Figure 1. Outcomes as a function of β and θ_1

Note: Here $2m + \beta = 1$, $k = 0.15$, and $\theta_2 = 0.95$, which ensures that A2 always works when given jurisdiction. Delegation maximizes welfare for $\theta_1 < 0.15$, while collaboration maximizes welfare for $\theta_1 > 0.15$.

somewhat anomalous because the "collaboration region" is non-convex. The intuition for this is that the condition $\tilde{\theta} < \theta^H$ holds when θ_2 and m are relatively high. An originator with a relatively low θ_1 will then collaborate because she cares about output and would be unable to contribute enough to collective output in a turf war.

Two general patterns emerge from this equilibrium. First, only high types are willing to work. Second, conditional upon A2 being willing to work, high-productivity and possibly low-productivity originators share. Only intermediate-productivity originators do not share, and so sharing and working may be non-monotonic in originator type.

2.2 Comparative statics and welfare

For the next result as well as the subsequent experiment, we will focus on the effect of competition (β). To distinguish between the effects of increasing competition and increasing the size of the "pie", we keep the size of the total reward constant by fixing $2m + \beta = W$ for some $W > 0$.

Figure 1 illustrates the equilibrium outcomes as a function of β and θ_1 for a set of parameters satisfying $\theta_2 > \theta^H$ and $W = 1$. For $\beta \in (0, 0.83)$, $\theta^H < \tilde{\theta}$ and the outcome pattern is delegation → collaboration. For $\beta \in (0.83, 0.87)$, the delegation → collaboration → turf war → collaboration pattern appears. Finally for higher values of β, $\theta^H > \tilde{\theta}$ and the pattern becomes delegation → turf war → collaboration.

The figure also helps to clarify the welfare implications of the game. The agents' joint welfare increases by $(2m + \beta)\theta_i - k$ if agent Ai works. Thus if this quantity is positive for both agents, then collaboration maximizes welfare. Under the parametric assumptions from Figure 1, collaboration is efficient whenever $\theta_1 > 0.15$, and referral or delegation is efficient otherwise. The equilibrium is therefore inefficient when a turf war occurs, but also when delegation occurs for $\theta_1 > 0.15$. Inefficiencies are therefore possible across all values of β when θ_1 is "moderate," but somewhat counterintuitively, the range of values for which such inefficiencies occur is not minimized when β is smallest. Rather, moderate values of β come "closest" to producing efficient outcomes.

Proposition 2 generalizes this figure and presents some basic comparative statics on the most important outcome regions.

Proposition 2 (Comparative Statics)
The set of θ_1 values for which a turf war occurs is increasing in β and weakly decreasing in k. The set of θ_1 values for which delegation occurs is decreasing in β and increasing in k. Specifically, for $\theta_2 \in (\theta^H, 1)$, if $\theta^H < \tilde{\theta}$ then comparative statics are:

Region	Outcome	β	k
$(0, \theta^H)$	delegation	decreases	increases
(θ^H, θ^-)	collaboration	ambiguous	decreases
(θ^-, θ^+)	turf war	increases	constant
$(\theta^+, 1)$	collaboration	decreases	constant

And if $\theta^H > \tilde{\theta}$, then comparative statics are:

Region	Outcome	β	k
$(0, \tilde{\theta})$	delegation	decreases	increases
$(\tilde{\theta}, \theta^+)$	turf war	increases	decreases
$(\theta^+, 1)$	collaboration	decreases	constant

Proposition 2 shows that the observation about the effect of β on outcomes from Figure 1 is general. Since θ^H is decreasing in β, the reduction in delegation implies an expansion in the collaboration region when there is no turf war region, i.e., in the first expression in Proposition 1(iii). Thus when both agents have jurisdiction, *increasing the prize induces efficient outcomes* for a wider range of θ_1. While the well-known effort inducing effect of the prize is always underlying, a turf war emerges for a large enough prize. As a prescription, a principal would therefore want to increase β (at the expense of m) up to the point where turf wars become possible. For values of β that generate a turf war, increasing β has the opposite effect of reducing the region where efficient outcomes can occur.

We finally make two observations about the role played by effort costs in this model. First, unlike β and m, increasing k never encourages collaboration. However, when $\theta^H > \tilde{\theta}$ and $\theta_2 \in (\theta^H, 1)$ (so that A2 always works) increasing k has no effect. Second, in the special case of costless effort, collaboration is non-monotonic. It is easily verified that $k = 0$ implies $\theta^H = \theta^L = 0$, so both agents always work. It follows that the outcomes of indifference, referral, and delegation cannot occur in equilibrium. The equilibrium is characterized by Proposition 1(iii), where $\theta^H < \tilde{\theta}$. Collaboration therefore occurs for both low and high productivity originators, with a turf war resulting for intermediate productivity.

3 Experimental design

In this section we present the results from a laboratory experiment used to test the more notable implications of our model. In particular, we examine the nonlinear effect of competition (β) on production and welfare. As with the comparative statics in Section 2.2, we focus on the case where the total reward is constant and is given by $W = 2m + \beta$. In other words, we compare situations that differ only in the importance of the incentive to compete as a fraction of the total compensation.

In the experiment, subjects were grouped in pairs. In each pair, one subject played the role of A1 (the originator) and the other played the role of A2. As in our model, A1 first decided between keeping, referring, or sharing. Subsequently, A1 and/or A2 chose between exerting effort or not. The subjects' monetary payoffs were based on equation (2) and were calculated in points. In all our treatments, we set $k = 220$ points and $W = 380$ points. Since the detrimental effects of competition occur when A2's productivity is high (see Proposition 1), we set $\theta_2 = 0.95$ throughout. The parameters that we varied were A1's productivity, which could take values $\theta_1 \in \{0.55, 0.75, 0.95\}$, and the size of the prize, which could equal $\beta \in \{57, 190, 304, 361\}$ points (these values of β imply $m \in \{161.5, 95, 38, 9.5\}$ points respectively). To facilitate the interpretation of our results, from now on, we normalize W, k, β, and m such that $W = 1$. This way, $\beta \in \{0.15, 0.50, 0.80, 0.95\}$ is simply the fraction of the total reward that is due to the competitive prize. The three values of θ_1 and the four values of β give us twelve treatments, each corresponding to a parameter combination. We refer to each treatment by these two values (e.g., treatment $\theta_{95}\beta_{15}$ corresponds to the case where $\theta_1 = 0.95$ and $\beta = 0.15$).

In the experiment, subjects played 60 periods (repetitions) of the game. However, in order to approximate play in a one-shot game, subjects were informed that they would be randomly rematched at the beginning of each period with another subject in the room and that they would not be able to identify other subjects (there were sixteen subjects per session). We rematched subjects within a matching group of eight, which has been shown to be sufficiently large to eliminate repeated-game effects (e.g., see Camera and Casari 2009). In addition, subjects knew that they would be paid the outcome of only one period, which would be randomly selected at the end of the experiment (the same period was paid for all subjects in a session).

Each session was divided into four parts of 15 periods each. The payoffs in each part were based on one value of $\beta \in \{0.15, 0.50, 0.80, 0.95\}$. In the instructions, subjects were told that the payoffs of the game would change during the experiment and that they would be informed of the change when it occurred. At the beginning of each part (i.e., in periods 1, 16, 31, and 46), subjects were shown the payoffs implied by the respective β and were given as much time as they wanted to evaluate the change. In order to control for order effects, each session was run using a different sequence of βs. We ran one session for each of the 24 possible sequences.

Subjects were randomly assigned to the role of A1 or A2 at the beginning of each period. Subjects knew that the productivity of A2 would always be $\theta_2 = 0.95$ and that the productivity of A1 would be randomly determined every period among the values $\theta_1 \in \{0.55, 0.75, 0.95\}$.

Given the complexity of the game, we had subjects play multiple periods to give them the opportunity to learn. We think that this is desirable as, initially, subjects in the laboratory might not have the same understanding of the game as players in the field. To further facilitate learning subjects were given information of the outcome of the game and their earnings at the end of each period. Moreover, instead of implementing $\omega_i(x_1, x_2)$ as i's probability of winning the whole prize, we implemented $\omega_i(x_1, x_2)$ as i's share of the total prize. This change has the advantage that it reduces the amount of noise when subjects in the role of A1 choose to share jurisdiction, which makes the consequences of sharing easy to see *ex post*.[20]

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[20] The disadvantage of implementing ω_i as i's share is that we are unable to test whether, in practice, risk aversion plays an important role in the sharing decision (we assume players are risk neutral in the model). Experimental evidence comparing winner-take-all and proportional-prize contests finds that the former results in higher effort and lower efficiency than the latter (Cason et al. 2010). In our experiment, this difference ought to play less of a role as effort cannot be high-enough to reduce efficiency.

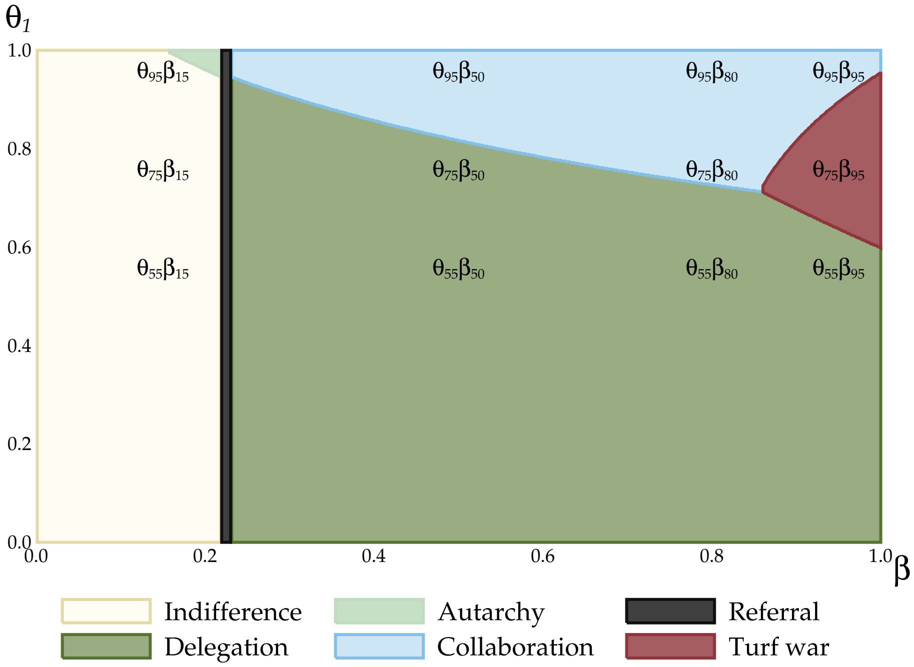

Figure 2. Predicted outcome as a function of θ_1 and β

Note: Predicted equilibrium outcomes according to Proposition 1 for $\theta_1 \in (0,1)$, $\beta \in (0,1)$, $W = 1$, $\theta_2 = 0.95$, and $k = 0.58$. The twelve treatments implemented in the experiment are shown at their corresponding values of θ_1 and β.

We ran the experiment in the CELSS laboratory of Columbia University in the fall of 2013. Subjects were recruited with an online recruitment system (Greiner 2015) and the computerized experiment was programmed in z-Tree (Fischbacher 2007). We used standard experimental procedures, including random assignment of subjects to roles and treatments, anonymity, neutrally worded instructions, dividers between the subjects' cubicles, and monetary incentives. A sample of the instructions is available in the appendix. In total, 192 subjects participated in the 90-minute long experiment. Each subject took part in only one session. Total compensation, including a \$5 show-up fee, varied between \$9 and \$33.30 and averaged \$23.32.

3.1 Predictions

Figure 2 depicts the predicted equilibrium outcome for all values of θ_1 and β given the other parameters in the experiment (i.e., for $W = 1$, $\theta_2 = 0.95$, and $k = 0.58$). The figure also shows the twelve treatments implemented in the experiment. These parameter combinations were chosen in order to obtain three different patterns as we increase β depending on the productivity of A1. For A1s with low productivity, $\theta_1 = 0.55$, increasing β results in the pattern: indifference → delegation. For A1s with high productivity, $\theta_1 = 0.95$, increasing β results in the pattern: indifference → collaboration. Finally, for A1s with intermediate productivity, $\theta_1 = 0.75$, increasing β results in the pattern: indifference → delegation → collaboration → turf war. While this last pattern is arguably the most interesting one, observing the results for the other two patterns allows us to test whether the detrimental effect of increasing competition occurs when the model predicts it will.

Based on the model's predicted equilibrium strategies, we formulate hypotheses for the mean behavior we ought to observe in the experiment. For simplicity, to formulate hypotheses, we group individual treatments according to the model's predicted outcomes. The hypotheses are visually presented in Figure 3. The figure presents what the mean actions taken by A1s and A2s would be if they behave according to Proposition 1.

Going from the top-left to the bottom-right, the first three graphs show the predicted fraction of times A1s choose to keep, refer, or share jurisdiction. The next four graphs show the predicted fraction of times A1s/A2s exert effort depending the previous jurisdiction choice. Lastly, the eighth graph shows the predicted total welfare as a fraction of the maximum possible welfare in the experiment (i.e., the sum of the agents' realized payoffs as a fraction of the sum of the agents' payoffs if they both have high productivity, share jurisdiction, and exert effort). Note that while we have a prediction for effort in all cases, when the prediction is indifference there is no clear prediction in A1's jurisdiction decision.

4 Results

In order to observe how subjects behave compared to the theoretical predictions, Figure 4 presents the mean actions taken by A1s and A2s over all periods, pooling treatments according to the model's theoretical predictions.[21] To make comparisons easier, Figure 4 uses the same structure as Figure 3: the top three graphs show the mean fraction of times A1s choose to keep, refer, or share jurisdiction; the next four graphs show the mean fraction of times A1s/A2s exert effort depending on A1's jurisdiction choice; finally, the eighth graph shows mean total welfare (i.e., the sum of the agents' payoffs as a fraction of the sum of the agents' payoffs if they both have high productivity, share jurisdiction, and exert effort). To provide a visual representation of the variance of each mean, the figure also displays 95% confidence intervals, which we calculated with regressions using treatment dummy variables as independent variables and clustering standard errors on matching groups. We used a multinomial probit regression for the jurisdiction choice, a

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[21] On average, each subject played 15 periods when the equilibrium prediction was indifference, 20 periods when it was delegation, 20 periods when it was collaboration, and 5 periods when it was a turf war.

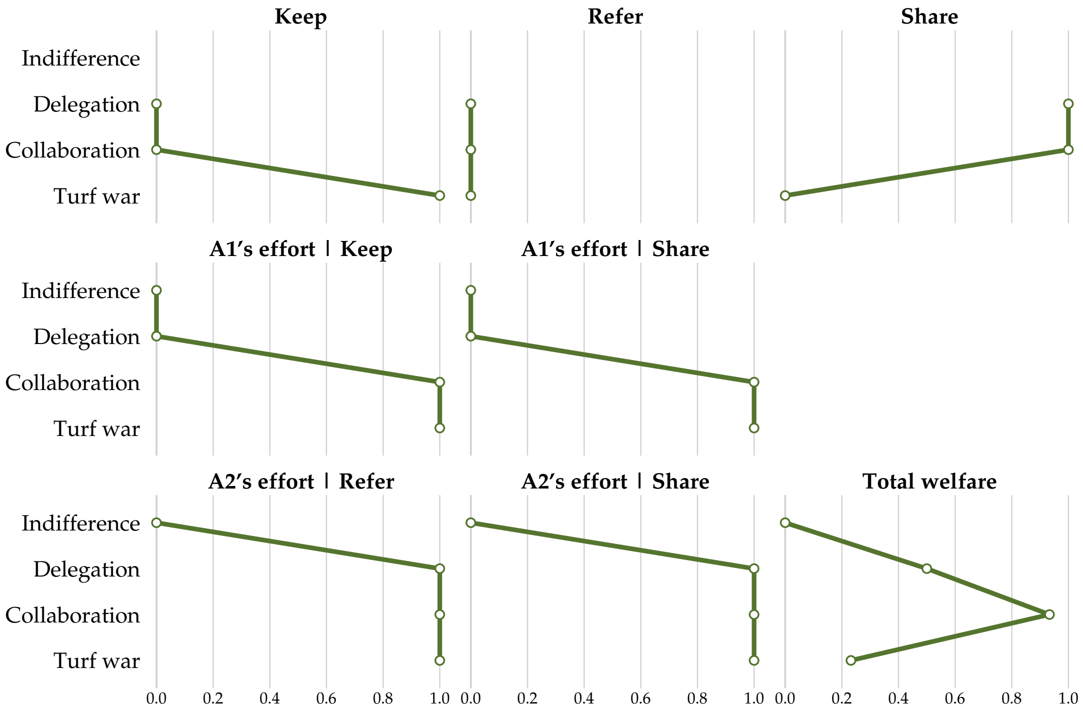

Figure 3. Predicted mean behavior according to Proposition 1

Note: Predicted mean actions according to equilibrium strategies. From the top-left to the bottom-right: the first three graphs show the predicted rate at which A1 keeps, refers, or shares jurisdiction; the next four graphs show the predicted effort rate of A1/A2 depending on A1's jurisdiction choice; and last graph shows the predicted total welfare as a fraction of the maximum possible welfare.

probit regression for each effort choice, and an ordered probit regression for welfare (these regressions are available in the appendix).

To evaluate whether the differences observed in Figure 4 are statistically significant we use the fact that all subjects participated in the four predicted outcomes, which allows us to evaluate the effect of the equilibrium predictions at the individual level. However, since subjects repeatedly interacted with each other within matching groups, we construct our independent observations by averaging the subjects' behavior within each matching group. This procedure gives us 24 observations per equilibrium prediction. Given that we are performing multiple pairwise tests for each variable, we determine statistical significance based on Bonferroni-adjusted p-values.[22] The appendix contains the resulting p-values for all pairwise tests. Moreover, it also includes the results of doing these comparisons using regressions. The regressions' results are consistent with those of the nonparametric tests.

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[22] For the jurisdiction decision, we multiply p-values by 18 since we run one test per pairwise comparison for each of the three outcomes (keep, refer, and share). For A1's/A2's effort choice, we multiply p-values by 12 since we run one test per pairwise comparison for each jurisdiction choice. Lastly, for welfare, we multiply p-values by 6 since we run one test per pairwise comparison.

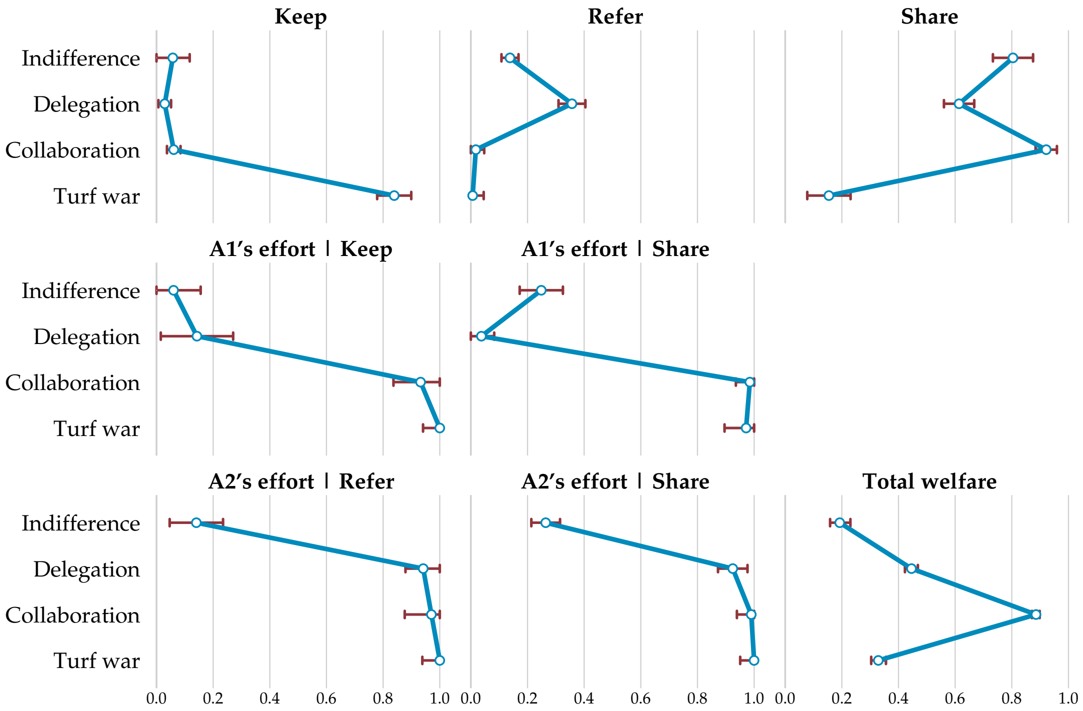

Figure 4. Means of selected variables by equilibrium prediction

Note: From the top-left to the bottom-right: the first three graphs show the mean rate at which A1 keeps, refers, or shares jurisdiction; the next four graphs show the mean effort rate of A1/A2 depending on A1's jurisdiction choice; and last graph shows mean total welfare as a fraction of the maximum welfare. Error bars correspond to 95% confidence intervals.

By and large, we find that the subjects' behavior fits well with the main predictions of our model. Starting with the effort decision, we observe that effort rates are high when exerting effort is in the subjects' self interest. Specifically, the fraction of A1s who exert effort is significantly higher when the equilibrium prediction is collaboration or turf war compared to when it is indifference or delegation (above 93% vs. below 25%, $p < 0.02$). Similarly, the fraction of A2s who exert effort is significantly higher when the equilibrium prediction is delegation, collaboration, or turf war compared to when it is indifference (above 92% vs. below 26%, $p < 0.01$).[23] Thus, the only discernible deviation from the theoretical predictions is that the effort rate of A1 under shared jurisdiction is significantly higher in indifference than in delegation ($p < 0.01$), which is driven by the noticeably high effort rate in indifference.[24]

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[23] There is one exception. In spite of the large difference in effort rates between indifference and turf war after A1 refers, this difference is not statistically significant. However, the lack of significance is due to there being too few independent observations for this test because referrals are very rare in turf war (they occur only 1% of the time).

[24] Although we see statistically significant differences in effort rates between delegation and collaboration/turf war, the magnitude of these differences is very small (8 percentage points or less). Therefore, we

In the preceding decision, we observe strong differences in A1's jurisdiction decision depending on the predicted equilibrium. Remarkably, the rate at which A1s keep jurisdiction is less than 6% when the equilibrium prediction is delegation or collaboration, but it increases significantly to 84% when the equilibrium prediction is a turf war ($p < 0.01$). Contrary to the model's predictions, however, we observe that A1s choose to refer jurisdiction to A2s when the equilibrium prediction is delegation resulting in significantly less sharing in delegation than in collaboration ($p < 0.01$). We will come back to this behavior when we analyze the individual treatments. Finally, although the model does not make a prediction for the jurisdiction decision when the equilibrium prediction is indifference, we observe that A1s choose to share jurisdiction most of the time (80%). Note that sharing in this case is consistent with the fact that effort rates are not exactly zero and are slightly higher when A1 shares.

Lastly, we observe that the total welfare in the experiment conforms with the predicted comparative statics. Namely, welfare increases significantly as we move from indifference to delegation and then to collaboration, but it subsequently decreases significantly when the prediction becomes a turf war ($p < 0.01$).[25] In fact, we clearly observe the detrimental effect of turf wars as total welfare is significantly lower when the equilibrium prediction is a turf war compared to when it is delegation even though the players' mean productivity is higher in the former case ($p < 0.01$).[26]

Next, we briefly discuss behavior in the individual treatments. We provide a detailed statistical analysis based on both regressions and nonparametric tests in the appendix. On the whole, we do not find that behavior in treatments with the same equilibrium prediction differ substantially from each other. There are some differences, however, which help explain the two most noticeable deviations from the model's predictions. First, we find that the high effort rate observed when the equilibrium prediction is indifference is driven by players with high productivity. This observation is consistent with the large

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do not consider them to be a substantial deviation from the theoretical predictions.

[25] Observed total welfare is close to the model's point predictions: it is slightly higher if the equilibrium prediction is indifference (0.19 vs. 0.00) or a turf war (0.31 vs. 0.23), and it is slightly lower if the prediction is delegation (0.45 vs. 0.50) or collaboration (0.89 vs. 0.94).

[26] In the appendix, we provide a brief analysis of the dynamics across periods. In short, we do not find that behavior changes dramatically over periods. However, within the 15 periods during which the payoff parameters are not changing, we do see some evidence that the subjects' behavior converges toward the equilibrium predictions. Specifically, we see less referrals over time and more keeping over time when the equilibrium prediction is a turf war. We also see less effort over time when exerting effort is not an equilibrium.

literature documenting that some individuals are willing to cooperate in social dilemmas (Fehr and Gächter 2000), particularly when the benefits of cooperation are high relative to the costs (e.g., Brandts and Schram 2001). Second, we find that the high referral rate when the equilibrium prediction is delegation occurs in the two treatments the difference between referring and sharing jurisdiction is the lowest. Therefore, once again, deviations from the model's predictions occur when such deviations are not very costly, a common finding in many experiments (see Goeree and Holt 2001).

In summary, our experimental results are in line with our model's theoretical results. First, we clearly observe how increasing the incentive to compete initially increases production as it provides an incentive to exert effort. Second, we also observe that further increases in competitive incentives can result in suboptimal jurisdiction decisions and a considerable reduction of production (and welfare). Third, we find that such turf wars occur when the productivity difference between A1 and A2 is neither too large nor too small.

5 Discussion

The goal of this paper is largely positive: we attempt to formalize the popular notion of turf wars in organizations. As we argue, the minimal necessary components of a turf war are joint production, competition, and property rights over jurisdiction. From this starting point, our model produces a unique equilibrium in which high-productivity originators share and high-productivity partners exert effort. One implication is that turf battles hurt most when collaboration is most needed; that is, when originators have moderate productivity. Perhaps most prominently, it shows that the reward from competition, β, can both help and hurt collaboration. While competition always mitigates moral hazard and free riding by inducing effort, high levels of competition can encourage originators to "go it alone".

Despite their ubiquity, turf wars are difficult to observe directly. In fact, inefficient lack of cooperation is present and most prominent precisely when the failure to share a task is hard to monitor and hence discipline directly. Our experiment therefore sought to test the model's predictions about originator sharing behavior when there is an able partner willing to work. The main predictions about the role of competitive versus policy-motivated incentives are supported, and in particular there is support for the non-monotonic effects of competitive rewards on collaboration.

These experimental results are important in that they tell us that turf wars emerge with human players, whose behavior does not perfectly adhere to assumptions of own-payoff maximization. Note that this result is not due to the absence of deviations from the model's predictions. Instead, it is because the observed deviations do not substantially affect our model's more notable implication: the nonlinear effect of competition and productivity on production and welfare. Initially, this finding might seem odd given the large literature arguing that intrinsic motivations to cooperate are common (Fehr and Gächter 2000) and can cause large general increases in cooperative behavior (Camerer and Fehr 2006). However, note that we do find that subjects share more often and exert more effort than predicted by own-payoff maximization. It is just that these deviations occur only when the equilibrium prediction is indifference, situations where competition between agents is low and everyone has an incentive to free-ride. These findings are consistent with evidence of crowding out of intrinsic motivations to cooperate when agents compete with each other (Brandts et al. 2009; Buser and Dreber 2016) or when cooperation is a dominant strategy for other players (Reuben and Riedl 2009; Glöckner et al. 2011).[27] This finding also suggests that many of the proposed behavioral solutions to improve cooperation in organizations, which are based on our understanding of intrinsic incentives in social dilemmas (e.g., Gächter 2007), are unlikely to prevent turf wars from occurring.

While we view our basic model as capturing a necessary and sufficient condition for turf wars, other factors may also matter. In the appendix, we developed extensions to the basic model that explore the effects of a fixed-sized prize, asymmetric information, a large set of agents, and continuous effort. In these extensions, the model's main insights persist. In particular, we see a "turf war" emerging when the originator's productivity is moderate and the competitive pressure is high, which suggests that turf wars are indeed a robust phenomenon.

An important question concerns the way in which effort is aggregated. In our game theoretic model, outputs are perfect substitutes. The appendix also provides an extension where we allow for varying degrees of substitutability and complementarity in the agents' efforts. The results from this extension suggest that returns to scale and complementarities

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[27] We should also point out that turf wars are not easily avoided if one assumes some agents possess commonly-cited motivations for cooperation such as inequity aversion Fehr and Schmidt (1999), conditional cooperation Keser and van Winden (2000), or reciprocity Dufwenberg and Kirchsteiger (2004); Falk and Fischbacher (2006). On one hand, A1s with moderate productivity who share jurisdiction expose themselves to disadvantageous inequality, which makes sharing even less desirable. On the other hand, even if sharing triggers a desire to cooperate/reciprocate in A2, it is not possible for A2 to act on this desire: refraining from exerting effort makes the sharing decision inconsequential while exerting effort hurts A1.

can affect sharing patterns in important ways. Sharing with a given agent becomes easier if there are production synergies but is harder in their absence. In fact, in an environment with rapidly diminishing returns to collaborative effort, a hypothetical principal might actually want autarchy.

The next logical step is to think of conditions where turf wars are ameliorated. In our model, agents are limited by being unable to strike bargains to divide the surplus with either each other or the principal. Moreover, we also do not consider organizational solutions such as the selection of agent types, or incentives provided through oversight or contracts. Yet, the model allows us to speculate on some possible remedies. For example, a principal could use a performance cutoff below which β is not awarded to any agent. This scheme might correspond to an organization's implicit threat to fill a higher position with an outsider rather than promoting from within. This might produce collaboration by reducing the payoff from autarchy, but it may also reduce the incentive of certain agent types to work.

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