Sabotage in Contests: A Survey*

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May 9, 2015

Abstract

A contest is a situation in which individuals expend irretrievable resources to win valuable prize(s). 'Sabotage' is a deliberate and costly act of damaging a rival's likelihood of winning the contest. Sabotage can be observed in, e.g., sports, war, promotion tournaments, political or marketing campaigns. In this article, we provide a model and various perspectives on such sabotage activities and review the economics literature analyzing the act of sabotage in contests. We discuss the theories and evidence highlighting the means of sabotage, why sabotage occurs, and the effects of sabotage on individual players and on overall welfare, along with possible mechanisms to reduce sabotage. We note that most sabotage activities are aimed at the ablest player, the possibility of sabotage reduces productive effort exerted by the players, and sabotage may lessen the effectiveness of public policies, such as affirmative action, or information revelation in contests. We discuss various policies that a designer may employ to counteract sabotage activities. We conclude by pointing out some areas of future research.

JEL Codes: C72; C91; C92; D72; D74; M51; M52.

Keywords: Contest; Tournament; Sabotage; Survey.

*This study is forthcoming in *Public Choice*. We thank William Shughart II (the Editor), three anonymous referees, Atsu Amegashie, Loukas Balafoutas, Luis Corchón, Richard Havell, David Malueg, Stephen Martin, Johannes Münster, David Rojo-Arjona, Santiago Sanchez-Pages, Fangfang Tan, Iryna Topolyan, the participants at the 2015 BRiDGE Workshop on Contests in Bilbao, and the seminar participants at the University of East Anglia for useful comments. Any remaining errors are our own.

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The king may be threatened by dangers in the interior or in the remote regions, particularly when he is about to start on an expedition. An internal rebellion is one led by a Crown Prince, the Purohita (the priest), the chief of defence or a minister.... An internal rebellion is more dangerous than one in the outer regions because it is like nurturing a viper in one's bosom.

- Kautilya, *Artha Shastra* [*Economic Science*], c. 4th Century BC, p. 160.

1 Introduction

Sabotage is ubiquitous in everyday life. A very early mention of sabotage was by Kautilya, the Prime Minister of Chandragupta Maurya (the first King of the Maurya Kingdom in ancient India) in 400 BC. The *Cambridge Dictionary* defines sabotage as 'to damage or destroy equipment, weapons or buildings in order to prevent the success of an enemy or competitor'. In the context of labor economics, Lazear (1989, p. 563) defines sabotage as "any (costly) actions that one worker takes that adversely affect the output of another". Although the concept of sabotage is quite familiar, the day-to-day definitions and understandings of sabotage vary across contexts, places and times. In the industrial organization literature, sabotage is connected with the act of 'raising rival's cost' (Salop and Scheffman 1983). The early literature on labor issues considers sabotage to be the intentional employment of lower level efficiency by laborers in response to lower wages offered (Pouget 1912).[1] In each of these cases, individuals employ strategies that are intended to damage someone else's success rather than of improving their own. Sabotage has a similar connotation in contests. A deliberate and costly act by one player to damage the performance of another in a contest is, in general, termed sabotage. In the current study, we review the economics literature on sabotage from the perspective of contests.

Formally, contests are situations in which players expend costly resources to win a valuable prize and, irrespective of the outcome, all of the resources expended become sunk. Examples of

[1] Veblen (1921, p. 38) defines sabotage as the "conscientious withdrawal of efficiency."

such situations include sports, lobbying, job interviews, promotion tournaments, research funding applications, legal disputes, war, patent races, and advertising. In each of these circumstances, players have the opportunity to expend resources to improve their own probability of winning the prize. Often, they also have the opportunity to expend resources to reduce another contestant's probability of winning the same prize. Following a major part of the literature, we term the resources expended to increase one's own probability of winning as 'effort', and those expended to reduce rivals' probability of winning as 'sabotage'. Because the players' winning probabilities always sum to 1, sabotage indirectly improves one's likelihood of winning the prize.[2] However, this type of behavior often violates social norms and is illegal and costly – making sabotage an expensive strategy. Despite this, such behavior is widespread, as the following examples indicate:

- The steady decline of Microsoft since 2000 under CEO Steve Ballmer is attributed partly to the new employee review system introduced by him (Oremus 2013). In this system, employees are evaluated relative to each other, top performers receive bonuses and promotions, whereas those at the bottom often have to fear for their jobs. The review system encourages employees to do almost everything they can to improve their ranking relative to their peers. For instance, a Microsoft engineer reported that "people responsible for features will openly sabotage other people's efforts." Sabotage was undertaken subtly by withholding information from colleagues to ensure that they did not get ahead in the rankings.

- Businesspeople often resort to costly strategies that are employed for the purpose of damaging the competitors' business. Friedman (1998, p. 577) describes such a business malpractice that occurred in the 1890s. John H. Patterson, the owner of the National Cash Register Company, fielded a special type of a counterproductive salesman. They were not required to promote their own product; instead, their job was to follow the salesmen of rival firms from shop to shop and to convince the customers to cancel any order that had just been placed. In this way, the market remained open for Patterson to sell his own cash registers in the near future.

[2] Here, we do not consider the cases in which there might be a tie or no winner is selected. The intuition behind sabotage, however, remains the same for such cases.

- In many marketing campaigns, firms stress their rivals' weak points. One such example is Progresso's famous advertisements, which highlighted that its rival Campbell's offered 95 soups containing monosodium glutamate (MSG). This led to a 4%-5% decline in Campbell's US soup sales (Lubin 2011).

- Sabotage is common also in political campaigns in which the opponents are discredited and often denigrated. In the 1997 general election cycle, the UK's Conservative Party broadcast an ad with a picture of then-Labor Party leader Tony Blair, replacing his eyes in the picture with demonic ones.

- Political imprisonment can be seen as an extreme form of such sabotage in political contests. As an example, consider Aung San Suu Kyi, who was placed under house arrest in 1990 when her National League for Democracy received 59% of the votes in the Burmese general election.

- Stealing crucial information from a political or commercial rival is also not uncommon. One such example is the set of events that led to the 'Watergate scandal' in 1972. US President Nixon and the *Committee for the Re-Election of the President* designed a plan that involved, among other illegal activities, breaking into the Democratic National Committee headquarters at the Watergate complex to collect information that could be used against the Democratic Party in the election.

- 'Scorched earth' is a famous strategy in warfare and corporate takeover battles. In warfare, it involves troops burning any land, crops, or trees as they retreat so there are no supplies available to the advancing enemy army. In corporate takeover battles, the strategy describes actions that a firm undertakes to make the proposed takeover unattractive to the acquiring firm, such as liquidating its valuable and desirable assets and assuming new debt obligations.

- Female satin bowerbirds view bowers, i.e., decorated nests, as indicators of male quality in mate choice. As a consequence, male satin bowerbirds often destroy the bowers of other males to gain an advantage in sexual competition (Borgia 1985).

All of these examples, although in various different contexts, convey essentially the same message. However, because these examples often resemble other seemingly similar contest-driven behaviors, it is important to distinguish acts of sabotage from behaviors such as 'punishment' (Abbink et al. 2010), 'nastiness' (Zizzo and Oswald 2001; Abbink and Sadrieh 2009), 'risk taking' (Genakos and Pagliero 2012), and 'cheating' (Preston and Szymanski 2003). The main difference comes from the fact that sabotage acts are carried out to damage others and are driven by the material benefits for the saboteur.

When an agent *punishes* someone else, this typically happens either because the person being punished is not following an objective norm or because the agent is motivated by fairness issues. Unlike sabotage, the punishment oftentimes is not executed in expectation of a material benefit for the punisher. It is to be noted, however, that when a norm is subjective, a powerful agent may distort the norm in his or her own favor, making punishment and sabotage indistinguishable. This is what happened when the military junta in power 'punished' Suu Kyi with imprisonment. However, in the end, it was an act of sabotage.

Agents who possess features of *nastiness* – as in the joy of destruction (Abbink and Sadrieh 2009) or in money-burning (Zizzo and Oswald 2001) games – may execute strategies similar to those of a saboteur. However, although there might be intrinsic motivation for being nasty, employing that strategy does not necessarily produce a material benefit for the agent. Instead, sabotage behavior is motivated by the expected material benefit arising from raising the incremental probability of winning.

Similarly, an agent's *risky behavior* may or may not involve other agents, especially competitors. Although engaging in sabotage itself may be risky, to employ sabotage there needs to be a victim of sabotage, which is not a pre-condition for risky behavior.

The distinction from cheating, however, is not that clear. Oftentimes, an agent involved in *cheating* does so to illegally distort his own performance in a contest. A sabotaging agent tries (legally or illegally) to damage the performance of his rivals. Preston and Szymanski (2003) analyze several forms of cheating in sports and mention that those cheating activities, such as taking illegal

performance enhancing drugs, doping racehorses and intentional poor performance in a basketball game, are not sabotage. There are, however, other cheating acts that are inseparable from the act of sabotage. When an agent illegally damages the opponent, then it becomes both cheating and sabotage. One such example comes from boxing. In a 1962 heavyweight title fight, it is claimed that Sonny Liston applied a banned substance to the surface of his gloves that caused irritation to the eyes of the opponent Muhammad Ali (then known as Cassius Clay). The use of such an illegal substance was cheating, but because it hindered Ali's performance, it also was an act of sabotage.[3]

Because sabotage is common, important as well as different from other similar acts, a stream of research has investigated the means and consequences of sabotage. However, there is no comprehensive survey of the existing studies. Partial reviews of sabotage behavior, as parts of longer reviews, are provided by Konrad (2009, Chapter 5.3), on the theoretical literature, and by Dechenaux et al. (2012, Chapter 6.1), on the experimental literature. In addition, Amegashie (2015) recently provided a brief overview of sabotage in rent-seeking contests. In this study, we thoroughly review the economics literature of sabotage in contests, both in theoretical and applied terms. We cover the economics literature but do not consider literature from other areas of research, such as organizational behavior or political science, even though they might be related in terms of broader appeal.

The remainder of this survey is arranged as follows. In the next section, we provide a general specification of contests without sabotage and then introduce sabotage into this framework. Next, we discuss the consequences and welfare effects of agents engaging in sabotage, for the contest organizer and for third parties. Saboteurs may be discouraged in two main ways: reducing the benefits of sabotage or increasing its costs. We discuss these issues in detail and introduce examples. We conclude by pointing out the possible research contributions that are yet to be made.

[3] We thank Atsu Amegashie for providing us with the example.

2 Contests without sabotage

From a game-theory perspective, a majority of contests are two-stage games. In the first stage, the contest organizer sets the 'rules of the game', such as the structure of prizes, participation costs, number of contestants, and so on. The contestants observe these rules and choose their competitive activities in the game's second stage.[4] The early contest literature (e.g., Tullock 1980 on rent-seeking; Lazear and Rosen 1981 on tournaments; Hillman and Samet 1987; Hillman and Riley 1989; and Baye et al. 1996 on all-pay auctions) assumes that competitive actions are one-dimensional and affect the own 'output' or 'performance' in the contest positively. The allocation of prizes among contestants depends on all of the contestants' performances and, hence, on the contestants' actions. Typically, better performance relative to others makes a contestant more likely to receive a larger prize.

To formalize these arguments, suppose there are N risk-neutral contestants indexed by $i \in \{1, ..., N\}$. Each contestant chooses an action or 'effort' e_i. To simplify the exposition, we follow the path of most theoretical contest papers. We assume that there is a single prize for the winner that is valued at w_{1i} by contestant i, and $N-1$ identical (and lower valued) prizes for losers valued at w_{2i} by contestant i. We define the prize spread as $\Delta w_i := w_{1i} - w_{2i}$. Contestant i receives the winner's prize with probability $p_i = p_i(\boldsymbol{e}) \in [0, 1]$, where $\boldsymbol{e} = (e_1, ..., e_N)$ denotes the vector of contestants' efforts and $\sum_i p_i = 1$. p_i, often termed a 'contest success function' in the literature, which is non-decreasing in e_i, and non-increasing in $\boldsymbol{e}_{-i} = (e_1, ..., e_{i-1}, e_{i+1}, ..., e_N)$. Contestant i chooses his action to maximize his expected payoff

$$\pi_i = w_{2i} + p_i(\boldsymbol{e})\,\Delta w_i - c_i(e_i), \tag{1}$$

where $c_i(e_i)$ is the cost of his action. Stronger action (i.e., more effort) is assumed to be more costly; thus $c_i' > 0$.

[4] In some applications, such as war, no contest designer exists. In some other cases, such parameters are beyond the contest organizer's control. When parties lobby for a government license, for instance, the winner's prize is the profit that can earned by being awarded the license. In both of these situations, the game consists of only one (namely, the second) stage.

In many applications, no between-contestant asymmetry in prize valuations is assumed, i.e., $w_{1i} = w_1$ and $w_{2i} = w_2$, and, as a result, $\Delta w_i = \Delta w$ for all i. For most of the following, we will adopt the same assumption, while noting any exceptions.

From (1), it is easy to see that a contestant faces a simple tradeoff when deciding his optimal effort. By exerting more effort, he can increase his probability of receiving the winner's prize. However, he also increases the cost associated with the effort. The optimal effort depends on the contest design chosen in the first stage. The prize spread, for example, affects a contestant's gain from outperforming his rivals and thus his optimal effort. In many applications, it is assumed that the organizer receives some payoff, which depends on the vector of efforts, while he has to pay the contest's prizes. Thus, he may wish to design the contest in such a way as to maximize the difference between the payoff and the sum of contest prizes.

3 Rationale behind sabotage in contests

As indicated before, the allocation of prizes in contests typically depends on the contestants' *relative* performances. Therefore, the probability of receiving the winner prize could be increased either by boosting own performance (e.g., by choosing to exert more effort, as argued in the preceding section) or by damaging the performances of other contestants. If such destructive behavior is feasible, competitive activities are N-dimensional and given by $(e_i, \boldsymbol{s}_i)$ with s_{ij} $(j = 1, ..., N,\ j \neq i)$ being the action that player i takes to reduce player j's performance and $\boldsymbol{s}_i = (s_{i1}, ..., s_{ii-1}, s_{ii+1}, ..., s_{iN})$.[5] In turn, the probability of receiving the winner's prize would have to be restated as $p_i(\boldsymbol{e}, \boldsymbol{s})$, with $\boldsymbol{s} = (\boldsymbol{s}_1, ..., \boldsymbol{s}_N)$. This probability is non-decreasing in $\boldsymbol{s}_i$, but non-increasing in $\boldsymbol{s}_{-i} = (s_{1i}, ..., s_{i-1i}, s_{i+1i}, ..., s_{Ni})$. Dye (1984) and Lazear (1989) are the first economists to account for such destructive behavior in contests. They denote the actions s_{ij} as sabotage directed by player i against player j. Again, it is typically assumed that performing these actions is costly. Among

[5] This specification excludes the term s_{ii}, i.e., the possibility of sabotaging oneself. Although 'self sabotage' may seem improbable, Gürtler and Münster (2013) show that it is rational for a player in some special circumstances to sabotage himself. We discuss this issue again in Section 4.1.

its other components, those costs may contain punishment for detected sabotage, costs of hiding sabotage acts, and effort expended in implementing sabotage. Thus, the total costs now amount to $c_i = c_i(e_i, \boldsymbol{s}_i)$.[6] Taking these arguments into account, the payoff function in (1), specified in the preceding section, changes to

$$\pi_i = w_2 + p_i(\boldsymbol{e}, \boldsymbol{s})\,\Delta w - c_i(e_i, \boldsymbol{s}_i). \tag{2}$$

When deciding about sabotage activities, a player faces a tradeoff similar to the one associated with productive efforts. By sabotaging his opponents, the player increases his probability of winning but also his own costs. Therefore, the theoretical prediction is that players may well find it in their interest to sabotage others.[7]

Whether people in the field behave in line with this prediction can be answered only by looking at data on behavior in contests. Unfortunately, sabotage activities rarely are recorded, so that field studies of sabotage (except in sports) basically are absent. An early exception is the paper by Drago and Garvey (1998). They conduct a survey of Australian employees and find that employees tend to help each other less if their own compensation depends on relative performance. As sabotage can be understood as the opposite of help (because sabotage reduces another player's performance, whereas help increases it), their findings imply that sabotage is empirically relevant. This conclusion is confirmed by numerous laboratory experiments (Harbring and Irlenbusch 2004, 2005, 2008, 2011; Harbring et al. 2007; Falk et al. 2008; Vandegrift and Yavas 2010; Carpenter et al. 2010; and Gürtler et al. 2011), and field studies from sports (Balafoutas et al. 2012; Brown and Chowdhury 2014; and Deutscher et al. 2013).

[6] Beviá and Corchón (2006) is an exception. They assume that players share the aggregate output they produce and that their shares depend on the relative contributions to total output. By sabotaging the other players, a player increases his relative contribution, while at the same time total output declines. Hence, sabotage can generate an indirect as well as a direct cost.

[7] Standard procedures exist to show the existence of equilibria and to characterize them, given specific forms of the CSF and the cost function. We describe some in detail in Section 5. In addition, it is easy to see that contestants are more inclined to sabotage others if the probability of winning the prize is very sensitive to sabotage efforts. We revisit this issue also in Section 5.

4 Welfare effects of sabotage

The examples stated in the Introduction offer anecdotal evidence of sabotage, and the studies cited in the previous section establish that sabotage is empirically relevant as well. These observations prompt the investigation of the effects of sabotage on a contest's outcome, especially its welfare implications. The act of sabotage has several consequences, but it in general affects welfare adversely. It is easy to observe that the resources expended on sabotage behavior are unproductive and hence wasteful. Additionally, by definition, sabotage activities are aimed at reducing rivals' productive performances, thereby destroying valuable output. While these consequences of sabotage are either a direct implication of our model or evident without further explanation, the remaining consequences deserve further elaboration.

The anticipation of being sabotaged produces a discouragement effect, according to which the players lower their productive efforts. In extreme cases, sabotage may lead to an adverse selection of contestants in the sense that the best possible participants might abstain from participating altogether. In Subsection 4.1, we first determine who suffers the most from sabotage and then investigate the effects of sabotage on welfare. We consider several other perspectives on the effects of sabotage. Sabotage may prevent the contest organizer from allowing proper information flow. If affirmative action policies increase sabotage, the organizer may be apprehensive in employing such policies. Agents who do not actively participate in the contest, such as spectators in sports contests or voters in an election, also can be adversely affected if sabotage is present. We discuss such issues in Subsection 4.2. Finally, in Subsection 4.3, we briefly address the welfare effects of sabotage when regular efforts are themselves unproductive, such as in rent-seeking contests.

4.1 Victims of sabotage and related consequences

Many studies of sabotage in contests either consider situations with two contestants or focus on symmetric equilibria in which all players are subject to the same amount of sabotage. However, if a player faces at least two opponents, he may decide to reduce one player's output more strongly

than another one's. In those circumstances, the question that arises is the following: Which player is subject to the most sabotage?

One aspect of this question is the possibility of heterogeneity among contestants. A contestant would be indifferent to sabotaging different rivals if they were homogenous.[8] Heterogeneity may either occur ex ante, i.e., contestants may inherently be different in terms of efficiency, or it may occur ex post, i.e., in a multi-stage contest, one (ex-ante homogenous) contestant might perform better in the early rounds than his rivals. Ex-ante heterogeneity, under risk neutrality, can easily be captured by heterogeneity in prize values. If $\Delta w_i > \Delta w_j$, then it can be said that contestant i is more efficient than contestant j.

Determining optimal shooting strategies in truels (shooting contests between three players), Shubik (1954) already indicated that the best shooter may not necessarily survive the truel with the highest probability. This is because the other two players may focus their attention on the best shooter to eliminate him early from the contest. A similar logic has been proven to be true in the context of sabotage. In contests with at least three players, very able players are often sabotaged more heavily because they present the greater danger.[9]

To capture this argument formally, we put some additional structure on p_i. Suppose that each contestant's performance is denoted by y_i, which is a function of e_i and $\boldsymbol{s}_{-i}$. Assume further that contestant i receives the top prize if and only if his performance is better than all other contestants. Then, p_i can be restated as $p_i = P\left(y_i > \max\left\{y_1, ..., y_{i-1}, y_{i+1}, ..., y_N\right\}\right)$, where $P\left(\cdot\right)$ denotes the probability operator. Suppose that contestant i believes that contestant j is so able that j will beat all of i's other opponents or, in other words $\max\left\{y_1, ..., y_{i-1}, y_{i+1}, ..., y_N\right\} = y_j$. Then, p_i simplifies to $p_i = P\left(y_i > y_j\right)$, and i finds it optimal to sabotage contestant j only (because $\frac{\partial p_i(\boldsymbol{e}^*, \boldsymbol{s}^*)}{\partial s_{ik}} = 0$ for

[8] Of course, the contestant may find it optimal to sabotage more than one rival, in which case typically he would sabotage homogenous rivals equally. The decision to sabotage one or multiple rivals depends, among other things, on whether there are increasing or diminishing returns to sabotaging a single rival.

[9] See, for instance, Skaperdas and Grofman (1995), Chen (2003), Yumoto (2003), Münster (2007) or Gürtler and Münster (2010). Regarding the example of the Satin bowerbirds in the introduction, it is observed that bowers artificially decorated with exaggerated numbers of berries are subject to more destruction (Madden 2001).

all $k = 1, ..., N, k \neq i, j$), if he wants to sabotage anyone at all.[10]

The consequences of sabotage for the contest's organizer can be disastrous. Talented players may not want to participate in the contest at all if they anticipate sabotage (Münster 2007). The contest's organizer may thus be stuck with mediocre contestants. This type of adverse selection is particularly detrimental if the efforts exerted by the best players are pivotal in determining social welfare. Examples of such incidences are patent races or innovation tournaments with spillovers. In those situations, the greatest effort usually is correlated with a better quality product or process, and the act of sabotage may potentially degrade that quality.

Another consequence of the threat of sabotage is that in the early rounds of dynamic contests, players may not want to put forth much productive effort to avoid gaining a lead and thereby becoming the victim of sabotage in later rounds (Gürtler and Münster 2010). Gürtler and Münster (2013) obtain an even stronger result. They assume that contestants suffer psychologically from being sabotaged by others. Consequently, the contestants may decide to help others in the early rounds of a dynamic tournament or even engage in self-sabotage so as not to be targeted by the sabotage efforts of others in later rounds. Hence, the problem of sabotage may lead to an additional problem of demotivation. It is to be noted, however, that the results hold only if none of the competitors is beyond the reach of the other competitors before the final period begins. Otherwise, the winner of the tournament would be known before the start of the final round and sabotaging others would no longer make sense.

These theoretical findings are well supported by experimental studies. Gürtler et al. (2013) conduct experiments on dynamic three-person contests and find that players with a lead at the beginning of the final round are sabotaged more heavily than players who are not in a leading position. They also confirm that the prospect of being sabotaged at a later stage of the game reduces the incentive to work productively early on. A similar observation is made by Carpenter

[10] Beviá and Corchón (2006) investigate whether agents decide to sabotage others at all (i.e., whether the equilibrium is interior). In line with the above arguments, they show that if an agent is unwilling to sabotage another agent of some specific ability, he also does not sabotage any other agent of lesser ability.

et al. (2010). In the experiment of Carpenter et al. (2010), a competitor's opponents evaluate his performance subjectively. Players can sabotage other players by underreporting those players' performances. Carpenter et al. (2010) find that subjects indeed underreport rivals' performances, and this has a negative effect on incentives.

An interesting result is derived by Deutscher et al. (2013). In a theoretical model, they find that the more able contestants are sabotaged to a greater extent even in static two-player contests. The result depends on the assumption that the more able contestants have higher returns to productive effort, and productivity and sabotage are substitutes for each other. Because of the first assumption, less able contestants exert less productive effort, which, together with the second assumption, implies more sabotage. The authors test their predictions using data from German professional soccer matches and obtain results in line with their theoretical findings.[11] Vandegrift and Yavas (2010) conduct laboratory experiments studying two-person contests and find that better players are sabotaged more vigorously.

However, it is also theoretically possible that the best players are not sabotaged as much or as often and the stated problems do not materialize. Gürtler and Münster (2010) show that players may want to sabotage weak players in the early rounds of dynamic contests to eliminate them from the competition. Amegashie and Runkel (2007) consider a four-person (and thus two-stage) elimination contest. They find that the most able player may decide to help the weaker player (and thus sabotage the stronger player) in the other semifinal, whereas all other players only take actions that affect the outcome of their own semifinal. Finally, Gürtler (2008) considers a contest between two teams. He shows that it may be optimal to direct all sabotage activities against the weakest member of the opponent team. If team production is characterized by decreasing returns to effort and complementarities exist between individual efforts, this type of sabotage strategy reduces the opponent team's output most effectively.

[11] See also Ishida (2012) and Balafoutas et al. (2012). In a model with private abilities, Ishida (2012) finds that very able players who signal their ability early on are sabotaged more in two-player contests. Balafoutas et al. (2012) analyze data from judo matches and find that higher ranked players are sabotaged more often.

Balafoutas et al. (2012) and Dato and Nieken (2014) investigate the personal characteristics of contestants who are likely to be sabotaged. Balafoutas et al. (2012) analyze the interactions between ability and gender in sabotage decisions in judo world championships. Destructive strategies in judo, called 'Shido', are "intended to hinder the opponent's attack" and are penalized if "judged to be against the rules of the game".[12] Balafoutas et al. (2012) classify 'Shido' as sabotage and find that it is used more by players with lower world rankings and is used more against players with higher world ranking. However, no significant difference was found in sabotage behavior by gender. Instead of studying the effect of ability on sabotage, Dato and Nieken (2014) specifically investigate whether gender differences exist in sabotage behavior. In a real-effort experiment, they observe that men sabotage their opponents more than women do. In turn, in a mixed tournament between men and women, women are sabotaged more than men. Therefore, while men are more likely to win the tournament, they also incur higher sabotage costs. These two effects more or less even out, and the expected payoffs are similar for men and women.

4.2 Other welfare effects of sabotage

As we elaborate in this subsection, sabotage may also affect welfare by reducing the benefits from specific policies, such as performance feedback and affirmative action, as well as by reducing the utility of third parties not actively participating in the contest. Charness et al. (2014) run a between-subject laboratory experiment to understand the possible effect of sabotage in situations wherein subjects receive a fixed (i.e., performance-independent) wage. In different treatments, the subjects are required to perform a task requiring real effort. In one treatment, participants were not given any feedback about their relative performances, whereas in another treatment, they were so informed. In an additional treatment with feedback, subjects had the opportunity to expend resources to impair the performances of other participants (and hence to improve their relative

[12] Because 'Shido' is employed to reduce the effectiveness of the opponent's productive activity and is costly (owing to the possible penalty), by definition it is sabotage. Similarly, in soccer a 'foul' (Corral et al. 2010; Deutscher et al. 2013) and in horseracing an 'intervention' (Brown and Chowdhury 2014) are regarded as acts of sabotage.

ranking). It is found that although no explicit incentive to exert any productive effort existed, subjects actually expended effort in all treatments. Providing feedback improves performance significantly. However, when the subjects have the opportunity to sabotage each other, the final outcome is characterized by significantly less effort than in the treatment with feedback, but with no sabotage. This happens for two reasons: first, the subjects' performance is reduced by sabotage, and second, anticipating sabotage, the subjects exert less effort.

Affirmative action, such as handicapping some players or providing others with head starts are often employed in various contests to help contestants from disadvantaged groups.In our notation, affirmative action manipulates the function $p_i(\boldsymbol{e}, \boldsymbol{s})$, increasing a disadvantaged player's chances of winning and thereby inducing him to exert greater effort.[13] However, differentially favorable treatment of some subjects may also cause more sabotage, offsetting any welfare gains from affirmative action. Brown and Chowdhury (2014) consider a contest in which the designer utilizes policy tools to level the playing field for the contestants. They use data from the British Horse Racing Association. In a standard horse race, every horse is required to carry a minimum amount of weight. In handicapped races that aim to make the contestants more 'even', higher-ranked horses carry more weight than other horses. The authors show that the handicap works in the right direction, in the sense that it reduces the likelihood of the highest-ranked horse winning. The authors then include the possibility of sabotage. Often, a jockey intentionally bumps his horse into another one, impedes the paths of other horses on the track, or runs his horse dangerously to reduce the likelihood of other horses winning. Classifying these incidents as sabotage, the authors find that handicapping increases the likelihood of sabotage. Brown and Chowdhury (2014) conclude that handicaps, head starts or any other affirmative action policy tool meant to level the playing field should be used with caution because they can initiate and escalate sabotage behavior.

These studies illustrate that the existence of sabotage may make policies such as affirmative

[13] Brown (2011) shows that differences in ability might discourage less skilled players and thus lessen the overall effort exerted in the contest. To address this issue, contest designers often handicap the more able players or give head starts to the players with lesser ability, such as, e.g., helping historically disadvantaged demographic groups in college admissions, the labor market and on-the-job promotions.

action and information disclosure less effective. However, given the possibility of sabotage, whether total welfare is higher with the policies (compared to when the policies are not in place) is not clear.

It is also conceivable that sabotage affects agents who do not actively participate in the contest. Sabotage often is argued not only to be illegal, but also unethical and immoral. Baumol (1992) considers an innovation race in which one firm can sabotage the R&D efforts of a rival. This not only reduces the profit of the rival, but potentially also the social welfare gains stemming from the innovation and related positive externalities. Preston and Szymanski (2003) argue that because the results in most sport contests depend on relative performance, sabotage may be an effective way to outdo others, especially with a small number of players. However, sabotage may also reduce the attractiveness and productivity of the contest, thereby lowering one's expected return and leaving the overall effect ambiguous.

Balafoutas et al. (2012) show that sabotage indeed reduces the utility of spectators in a sporting match. A survey of spectators in the judo world championship shows that an increase in 'fouls' reduced the spectators' utility obtained from watching the match. One should consider, however, that the spectators' disutility from increases in destructive effort and the disutility from decreases in productive effort (owing to more sabotage) may be correlated. Whether the effect of destructive effort is significant, apart from the 'trickle down' effect of less productive effort, is an empirical question; Balafoutas et al. (2012) do not try to answer this question.

This third-party effect is prevalent in electoral contests in which it is possible for political parties to resort to counterproductive acts such as vote rigging, vote snatching, and political violence, to gain power or to prevent the opposition's supporters voters from voting. In a political economy framework, Chaturvedi (2005) shows that the party with less political support indeed will engage in more sabotage, which may diminish the general population's confidence in democratic processes, including that of voters and non-voters alike.

In a similar vein, it can be hypothesized that negative campaigning in markets or in elections may reduce the utilities of consumers and voters. We found no academic research in economics

that investigates the effects of negative product advertising on consumer welfare. In contrast, both theoretical and empirical studies document the effects of negative political campaigns on voters. Regarding the effect of negative campaigning on voter turnout, the *demobilization hypothesis* states that negative campaigns depress voter turnout, whereas the *stimulation hypothesis* suggests that exposure to negative campaigns may even increase voters' probability of voting. The field results, however, are inconclusive.

Soubeyran (2009) shows that sabotage may affect voters negatively, resulting in lower voter turnouts. He proposes a theoretical model of contest with attacks and defenses. In this model, two candidates choose between enhancing their own image (defense) and sabotaging the opponent's (attack). Soubeyran (2009) concludes that the effect of a negative advertising campaign on voter turnout depends on voter sensitivity to messages that attack a candidate's opponents. More specifically, when voter sensitivity to attack increases, candidates attack more, but the relation between attack and voter turnout may be non-monotonic. The empirical evidences are mixed. Ansolabehere et al. (1994) find that exposure to negative advertisements reduces intentions to vote. Freedman and Goldstein (1999),on the other hand, obtain data on the frequency of an advertisement being aired and on viewership to derive an estimate of advertisement exposure. They find that exposure to negative campaign advertisements appears to increase the probability of voting. Inconclusive results are found when they use a different measure of individual perceptions of the tones of campaign advertisements.

One final, relatively unexplored aspect of the negative welfare effects of sabotage is the costly investments undertaken to counteract sabotage by one's opponents. This may include defensive efforts to prevent sabotage in the first place, such as investment in security measures to prevent the theft of information since the 'Watergate scandal', as discussed in the Introduction, or a nation's investment in counterterrorism measures. These defense-against-sabotage costs are welfare-reducing because they are unproductive. Gordon et al. (2005), reporting to the FBI, show that US firms spend 8% to 24% of their IT budgets on data security measures, whereas state governments may spend up to $350 per employee annually to protect against potential threats. Hence, although

it has not been investigated thoroughly, the welfare effects of sabotage in this dimension can be significant.

4.3 Welfare effects of sabotage when subjects' efforts are unproductive

Up to this point, we assumed that efforts expended by contest participants are productive and that the tournament organizer thus wishes to induce high effort (as in business organizations and in sports). In some applications, such as rent seeking or conflict, however, players' efforts are themselves directly unproductive. In rent seeking contests, effort is aimed only at obtaining a larger share of an existing rent and thus represents a complete waste of resources (Tullock 1967, 1980; Bhagwati 1982). In such situations, some of the previous welfare implications are reversed and sabotage may even be beneficial from that perspective. The intuition is that the prospect of being sabotaged may reduce the motivations of contestants to exert effort, as argued in the literature (Gürtler and Münster 2010; Amegashie 2012), which would lead to a welfare gain. Two examples illustrate this point.

1. Consider a firm in which several employees compete for promotion. In many instances, the promotion decision is made by the employees' superior. Therefore, employees may work extremely hard to impress the superior with their outstanding performance. Alternatively, they may simply spend time and effort to influence the superior's decision, urging the superior to consider them for promotion or even bribing him.[14] If an employee repeatedly engages in such influence activities, it is conceivable that the other employees competing for the promotion will start to sabotage this employee. This, in turn, may discourage the employee from trying to influence the superior's decision by unproductive means, implying a welfare gain.

2. In political competition, politicians may supply inaccurate information to voters or may even tell lies to improve their chances of being elected. Exposing lies or inaccurate information could be understood as a particular form of sabotage that may be seen as very useful from society's perspective. Not only does this type of sabotage provide valuable information to voters so that

[14] Such influence activities were studied by Milgrom (1988).

they can make better voting decisions, but it also reduces the incentive to lie or provide inaccurate information in the first place.

5 Policies to restrict sabotage

A clear understanding of the occurrence and the consequences of sabotage allows one to design appropriate policies to overcome those issues. In this section, we address policies that economists have proposed as possible solutions to the problems related to sabotage. To understand these policies fully, it is helpful to take a closer look at the contestants' optimal sabotage activities. If we assume that an interior solution to the contestants' maximization problem exists and that the payoff functions are strictly concave, optimal sabotage activity s_{ij}^* is characterized by the condition

$$\frac{\partial p_i\left(\boldsymbol{e}^*, \boldsymbol{s}^*\right)}{\partial s_{ij}} \Delta w = \frac{\partial c_i\left(e_i^*, \boldsymbol{s}_i^*\right)}{\partial s_{ij}}, \tag{3}$$

which simply states that s_{ij}^* is chosen such that the marginal benefit to increasing s_{ij} (in terms of a higher probability of receiving the winner's prize) equals the marginal cost of effort. Hence, policies that are aimed at tackling the sabotage problem affect a contestant's decision by either reducing the marginal benefit from sabotaging opponents or, similar to the famous argument by Becker (1968), by increasing the (marginal) cost. We also discuss other policies besides these two that may be implemented to restrict sabotage.

5.1 Policies that reduce the benefits from sabotage

Let us begin with policies that are aimed at reducing contestants' benefit from sabotage. The most obvious policy in this respect, proposed by Lazear (1989), is to narrow the difference between the winning and losing prizes. If this gap is reduced, contestants have less incentive to win the contest. As a result, they are less willing to engage in costly sabotage.[15] Formally, with a narrower prize

[15] As shown by Chen (2003), it is also conceivable that the level of sabotage does not depend on the prize spread at all. However, this happens only under very restrictive assumptions about production and cost functions. See Proposition 4 in his paper and the discussion thereafter.

spread, the left-hand-side (LHS) of condition (3) becomes smaller and so must the right-hand-side (RHS), i.e., $\frac{\partial c_i(e_i^*, \boldsymbol{s}_i^*)}{\partial s_{ij}}$. Assuming c_i to be strictly convex, this implies a decrease in s_{ij}^*. By the same token, however, contestants are less willing to put forth productive effort. Thus, the policy comes at a cost to the contest organizer. Because of this cost, Drago and Turnbull (1991) propose not organizing a tournament at all if sabotage is a serious threat (i.e., to set the prize spread equal to zero) and to seek alternative ways of motivating the players to put forth productive effort. Bose et al. (2010) advance a similar argument. As explained before, however, experimental results by Charness et al. (2014) suggest that sabotage may occur as long as information regarding the players' performance ranking is available, even if the monetary rewards do not depend on this ranking.

The predictions concerning the effects of prize spread on players' decisions have found strong support from empirical and experimental studies. Garicano and Palacios-Huerta (2014), for example, analyze the effects of an increase in the number of points awarded for a win in Spanish football. They find that teams react by increasing both the number of attackers and the number of defenders (while reducing the number of midfielders) in the starting lineup. They interpret this observation not only as evidence of more vigorous productive efforts (attackers) but also of more sabotage (defenders) in response to the change in incentive structure. In line with the latter argument, the authors also find that the number of fouls committed increases after the change in the prize structure.

Corral et al. (2010) conduct a similar analysis with data from the 1994-1995 and 1995-1996 seasons of the Spanish First Division Football League. Again, the effects on sabotage activities of the change in the winning team's league points from two to three are investigated. As the reward increases, Corral et al. (2010) predict a rise in players' defensive efforts and thus a greater likelihood of a player being sent off the pitch. They find that when reward points increase, teams in the winning position are more likely to sabotage and to have a player disqualified from the game. Their results also suggest that when the goal difference in a match becomes larger, the likelihood

of a sending-off generally is smaller.[16]

Laboratory experiments conducted to analyze the sabotage problem in contests confirm the observation that sabotage levels increase in the prize spread (Harbring and Irlenbusch 2004, 2005, 2011; and Vandegrift and Yavas 2010). Contest organizers seem to understand the relationship between prize spreads and sabotage levels. As a result, they widen prize spreads and prefer tournament schemes to other incentive devices more often if sabotage is not feasible (Falk et al. 2008; Harbring and Irlenbusch 2011).

A second method of reducing contestants' benefits from sabotage is to increase the number of contestants. This possibility was first described by Konrad (2000). The argument goes as follows: if a player increases his productive effort, he increases his own output and thereby the probability of outperforming every single opponent. If, instead, he increases the level of sabotage directed against a particular rival, he reduces that rival's output and, hence, he increases the probability of outperforming that rival only. If the number of contestants rises, productive efforts become relatively more attractive compared to sabotage activities, and the sabotage problem is mitigated. Stated differently, sabotage directed against player j by player i constitutes a public good for all other contestants. This is because player i increases all other players' (except j) winning probabilities by sabotaging player j. Hence, the provision of the public good, i.e., sabotage, declines when more players participate in the game.

To present this argument formally, recall that in many situations it is assumed that contestant i receives the winner's prize if and only if his performance is the best overall, so that $p_i = P\left(y_i > \max\left\{y_1, ..., y_{i-1}, y_{i+1}, ..., y_N\right\}\right)$. When worker i chooses greater productive effort (i.e., when he increases e_i), the term on the LHS of the inequality in parentheses increases, making it more likely that y_i exceeds any of the y_j $(j = 1, ..., N, j \neq i)$. Instead, when worker i decides to sabotage worker j more than others (i.e., when he increases s_{ij}), y_j declines and it becomes more

[16] This implies that a larger ex-post performance difference reduces sabotage. That result is in line with the study by Brown and Chowdhury (2014), who find less sabotage in horseracing when the ex-ante ability difference is large. Overall, these studies suggest more sabotage between contestants with similar (ex-ante or ex-post) abilities.

likely that y_i exceeds y_j. The probability with which y_i exceeds any of the other contestants' performances, however, is not affected. It immediately follows that the larger the number of contestants competing for the prize, the greater is the benefit from increasing e_i relative to increasing s_{ij}.

Amegashie (2012) employs sabotage in a rent-seeking model in a different fashion. Similar to Harbring et al. (2007), he introduces a two-player Tullock contest with two stages. In the first stage, the players can expend costly resources to increase the marginal cost of their rival. In the second stage, given their marginal costs, they expend effort in a standard Tullock contest. The difference between this model and the majority of the relevant literature is that the sabotage does not affect the effort of the rival directly; instead, it affects the rival's performance by increasing his cost of exerting effort. Amegashie's results confirm the idea that sabotage is less relevant in larger contests with many participants. While closed form solutions for the general case of n players are impossible to derive, numerical simulations show that in large contests, players do not expend positive sabotage effort.

In spite of the importance of this theoretically robust argument, little evidence exists on the effects of the number of contestants on sabotage activities. Harbring and Irlenbusch (2008) find that tournament size does not affect sabotage activity. However, in their experiment, sabotage reduces the output of all of the opponents. As a result, the public-good problem outlined earlier disappears in such a setting.

Finally, Chen (2005) considers a specific form of contest: one in which the contestants are employees who compete for promotion to a vacancy in a higher tier of their firm's hierarchy. He shows that the firm may want to consider external candidates for the vacancy if the internal candidates perform poorly. If external candidates are admitted, the return to productive effort compared to sabotage increases for the internal contestants. The reason is simple and is related to the arguments concerning contest size. By exerting productive effort, an employee improves his chances of outperforming both internal and external candidates. Sabotage, however, can be directed only against internal competitors. Hence, if the firm considers external candidates for promotion, internal competitors substitute productive effort for sabotage. Formally, this argument could be

substantiated by writing p_i as $p_i = P\left(y_i > \max\left\{y_1, ..., y_{i-1}, y_{i+1}, ..., y_N, \bar{y}\right\}\right)$, where $\bar{y}$ denotes a fixed performance level that cannot be influenced by the contestants.

5.2 Policies that increase the cost of sabotage

The most obvious policy to raise the (marginal) cost of sabotage, $\frac{\partial c_i\left(e_i^*, \boldsymbol{s}_i^*\right)}{\partial s_{ij}}$, is to increase the punishment when sabotage is detected. In many contests, the maximum punishment that the contest organizer can inflict on a contestant is to strip him of the prize he had won. In a setting of cheating that is analytically similar to that of sabotage, Curry and Mongrain (2009) consider such a situation and investigate whether stripped prizes should be re-awarded to other contestants. They demonstrate that re-awarded prizes mitigate the wrongdoing. In the context of sabotage, if prizes are re-awarded, a contestant can expect to improve his relative ranking and to obtain a larger prize if other contestants whose sabotage activities have been detected are disqualified. By engaging in sabotage himself, the contestant risks missing the opportunity to receive a larger prize "for free", making sabotage a costly activity.

Several other policies that aim at increasing the cost of sabotage have been discussed in the literature. Lazear (1989) proposes separating contestants spatially to make it more difficult for them to sabotage each other. Consider the example of a firm that organizes a contest to motivate employees. Employees from different locations would find it harder to affect their opponents' performances than employees working in the same building or office.

When the contest organizer is able to influence contestant field ex ante, he may choose to let in only those players for whom sabotaging others is relatively costly. Players may incur some form of psychological cost while sabotaging others and this cost may vary across players. Similarly, players who suffer from relative deprivation or envy when being worse off than others incur lower costs of sabotage because sabotage reduces the probability of feeling deprived or envious (Kräkel 2000; Grund and Sliwka 2005). The contest organizer thus should admit only those players who do not suffer from relative deprivation or envy. Unfortunately, it is often difficult to observe the specific characteristics of a player, especially their states of mind. Furthermore, players do not have an

incentive to self-select into contests that are designed for their types (Lazear 1989). Mechanisms such as assessment centers may help to screen contestants, but those assessments will be far from perfect.

Balafoutas et al. (2012) report the results of a field study of the effects of sabotage costs. They rely on data from two consecutive judo world championships in 2007 and 2009 to analyze the effects of the cost structure on the use of sabotage. They specify productive activities (attacking strategies) and sabotage activities (defensive strategies – which are often penalized) in judo. A change in judo's rules in 2009 allowed the players to commit one act of 'sabotage' without penalty, hence reducing the cost of sabotage. Balafoutas et al. (2012) find that, as expected, the reduction in cost increased the total number of sabotage acts. Hence, it is suggested that when it is possible to monitor sabotage and impose costs upon it, a heavy penalty cost should be imposed.

Laboratory experiments have found that contestants retaliate when sabotaged and that the threat of retaliation deters players from sabotaging others in the first place (Harbring et al. 2007; Vandegrift and Yavas 2010). Retaliation thus acts as a type of additional indirect cost of sabotage. Of course, players must learn the identity of saboteurs to be able to retaliate against them. The contest should therefore be transparent in the sense that sabotage decisions should be observable publicly. Moreover, players should meet each other more than once to be able to retaliate. Retaliation, however, may not just benefit the contest organizer; it may also be used against him. If he treats the contestants badly, they may decide to sabotage each other to reduce the output that the contest organizer receives. This type of behavior is observed by Harbring and Irlenbusch (2005). They find that sabotage is more frequent if the organizer himself sets low prizes rather than if these low prizes are determined exogenously. Presumably, the psychological costs of sabotaging others are higher if the contestants were treated well by the contest organizer than if they were not. An immediate take-away is that the organizer should be generous toward the contestants to prevent them from engaging in sabotage. Finally, experimental results from Bolle et al. (2014) show that if retaliation itself can be retaliated against, then players might engage only in destructive behavior, i.e., retaliation against a saboteur might escalate the execution of destructive behavior in an upward

spiral over time and lead to the worst possible outcome. Hence, the designer will need to be very careful about allowing retaliatory actions.

The contest organizer may instead wish to affect the timing of sabotage decisions. Kräkel (2005) considers a model in which players decide to help or sabotage each other first and, after having observed those decisions, choose their productive efforts. He shows that a contestant may even want to help his opponent to make subsequent competition less equal and thus less intense. In other words, sabotaging the opponent would yield a close competition in productive efforts and, accordingly, raise the cost of productive effort. To lower this cost, players may abstain from sabotaging the opponent. Of course, the reduction in sabotage comes at a cost to the contest organizer because, contrary to the contestants, he suffers from the reduction in productive efforts.

5.3 Other policies

Policies to restrict sabotage exist that do not fall into either of the two categories described above. Brown and Chiang (2008), for instance, consider the tournament setting of Lazear (1989) and allow the players to form coalitions. It is assumed that positive externalities exist, implying that a coalition's probability of winning depends on its size. If such externalities are sufficiently salient, an equilibrium sub-coalition forms and sabotage activity declines overall. For a sufficiently small externality, a grand coalition exists and sabotage does not occur at all. Understandably, this type of policy may be feasible only for some specific situations and not for sports or workplace environments.

Given previous studies of sabotage, however, the most important policy may be restricting the provision of information to the contestants. Gürtler et al. (2013) argue that many of the outlined problems rely on the possibility of players observing each other's talents or past performances. Hence, the contest organizer should try to keep this type of information secret. If, for instance, the organizer does not reveal intermediate performance information to the contestants in a dynamic contest, they do not know which player has a lead and cannot direct their sabotage efforts at this particular player. As a result, incentives to expend productive effort in early rounds of the contest

are reinstated. Using experimental data, Gürtler et al. (2013) find that this type of restrictive information policy works in the sense that productive efforts in early rounds of dynamic contests increase.

There are some limits to this argument, though. In some settings, the tournament organizer simply is unable to fully restrict the flow of information. In repeated contestants, for example, the winners of the early rounds are announced publicly and so become common knowledge. It is then easy to infer that the winners were the high-performing contestants so that in future contests, it will be difficult to hide information about who the top performers are. A possible way to mitigate this problem is to introduce new contestants with unknown ability periodically. As Chen (2003) argues, including contestants from outside of an organization may reduce the likelihood of sabotage.

A further possibility for tackling the problems described earlier is to change the prize structure. Suppose that a single loser prize is awarded, but the contest offers $N-1$ winning prizes. Then, p_i is given by $p_i = P\left(y_i > \min\left\{y_1, ..., y_{i-1}, y_{i+1}, ..., y_N\right\}\right)$, and the contestants prefer to sabotage players of low ability to make sure not to end up in the last position (Yumoto 2003). As a result, very able contestants are willing to participate in such a contest. Moreover, in dynamic contests, players have an incentive to exert high productive effort in early stages to avoid lagging behind and being sabotaged harshly.

6 Conclusion

Sabotage is the exertion of destructive effort toward rivals with the intention of reducing their likelihood of winning a contest. Although sabotage is observed in various day-to-day situations, such as sports, on-the-job promotions, war, and rent seeking, and, moreover, a sizeable body of literature on this topic exists, that literature has not yet been thoroughly reviewed. This article fills the gap, focusing on the economics of sabotage in contests.

Both theoretical and applied studies agree on several points regarding sabotage. Sabotage is positively related to the value of the prize value to be won and negatively to the cost of engaging

in sabotage activities. Usually, saboteurs are more likely to target their ablest rivals and to do so more frequently. Circumstances exist in which sabotage, whether by one player or a coalition of them, offsets the gains from investing productive effort into a contest. That is because sabotage directly reduces the contest's collective output, discourages players from exerting productive efforts, and imposes negative externalities on third parties. Sabotage may be limited in several ways, viz. increasing the cost of sabotage, concealing information regarding contestants' abilities or performances, increasing the number of participants, and not leveling the playing-field among contestants with asymmetric abilities.

Sabotage has been studied extensively in the context of promotion tournaments. However, the sabotage problem may be relevant even if firms do not rely on tournaments to select employees to move up the organization's hierarchy. In many situations, firms find it in their best interest to offer wage contracts to their employees that depend on the employees' relative performances. Such wage contracts may, for instance, be optimal if individual performances are positively correlated and employees are risk-averse, so, in that case, relative performance evaluation (RPE) reduces the income risk that employees face (Holmström and Milgrom 1990). If an employee's wage depends on his performance relative to that of others, the incentive structure is similar to that in a tournament and, hence, sabotage is an issue. Sabotage may occur even if workers collaborate in teams (Auriol et al. 2002; Bose et al. 2010; Kräkel and Müller 2012).

Some interesting and relevant areas exist in which investigations relating to sabotage have yet to be conducted. The theoretical literature still needs to explore the issues of sabotage in contests with multiple prizes, in super games, and in dynamic/sequential games. The literature on issues relevant to contest design, such as seeding, prize distribution, or entry does not yet include sabotage. This is also true for contests that generate externalities such as networks, social preferences, and identities. Few attempts have been made to analyze sabotage in groups and in coalitions. Defensive measures against sabotage activities and the corresponding welfare implications likewise have not yet been studied. Most of the studies consider the normal efforts in contests as welfare enhancing and sabotage as welfare reducing. If, as considered in Section 4.3, contest efforts are considered to

be welfare reducing, then the corresponding behavioral implications will demand different welfare analyses. More fundamentally, each and every model involving sabotage possibilities assumes the overall probability of winning a prize to be fixed (at 1, for instance). However, in other cases, such as patent races, advertising, and some sporting events, this does not need to be true. An area of literature exists that addresses attack-and-defense strategies (see Grossman and Kim 1995 for an example), the analytical techniques of which often are the same as those used in analyzing sabotage. Comparisons of those two literatures still are pending.

Current empirical evidence on sabotage activities mostly comes from laboratory experiments, and the literature itself is also quite narrow. Issues such as sabotage in network games, the interaction between risk and sabotage, sabotage and contest design currently are almost untouched. Interesting issues also relate to post-contest sabotage in multi-stage or dynamic contests. Whether a player chooses to sabotage the opponent after a contest ends to reduce future competition is an empirical question and should be investigated. The body of field evidence regarding sabotage is not large, and most of the evidence is from sports contests. It will be useful to extend such investigations to areas other than sports. As discussed earlier, the welfare effects of sabotage in market or political environments remain to be studied and measured. Most theoretical and applied research on sabotage focuses on the 'effects' of sabotage or the 'material reason' for sabotage. However, because the nature of the act itself is fundamentally behavioral, it is very important to observe the theory through the lens of behavioral economists (for an example, see Mui 1995). Finally, to date, no field experiments on sabotage exist beyond the world of sports. Hence, opportunities to extend the literature in this area are both broad and deep.

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