Sabotage in Contests: A Survey*

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Abstract

A contest is a situation in which individuals expend resources in order to win valuable prize(s). 'Sabotage' is a deliberate, and often costly and illegal, act of damaging a rival's likelihood of winning the contest. It is done by exerting resources to negatively influence the effectiveness of a rival's efforts, or by increasing the rival's cost of effort, or by denying the rival access to resources. Sabotage can be observed in sports, war, promotional tournaments, political or marketing campaigns etc. In this article, we review the economics literature analyzing the act of sabotage in contests. We introduce a general structure and discuss the theories and evidence highlighting why sabotage occurs, the effects of sabotage on individual players and on overall welfare, and possible mechanisms to reduce the act of sabotage. We conclude by pointing out certain areas of future research.

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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 in the "Artha Shastra" (Economic Science) pp 160, Circa 4th century BC.

1 Introduction

Sabotage is ubiquitous in everyday life. The earliest mention of sabotage in an economic setting, to our knowledge, was by Kautilya, the Prime Minister of Chandragupta Maurya (the first King of the Maurya Kingdom in ancient India) in 400 BC. 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 personnel 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 the same vary across context, place and time. In the Industrial Organization literature, sabotage is connected with the act of 'raising rival's cost' (Salop and Scheffman, 1983). Early literature on labor issues considers sabotage as intentional employment of lower level efficiency by laborers in response

to lower wages offered (Pouget, 1912).[1] In each of these cases, however, individuals employ strategies that are intended to damage someone else's success instead of improving one's own. Sabotage has a similar meaning in contest literature too. A deliberate and costly act by one player to damage the performance of another in a contest is, in general, termed as sabotage. In the current study, we review the economics literature on sabotage in the perspective of contests.

Contests are situations in which players expend costly resources in order to win valuable prize(s) and irrespective of the outcome, all the resources expended become sunk. Examples of such situations include sports, lobbying, job interviews, promotional tournaments, research funding applications, legal disputes, war, patent races, and advertising – to name a few. In each of these circumstances, players have the opportunity to expend resources to improve their own probability of winning the prize. Often, however, they also have the opportunity to expend resources to reduce the probability of another contestant 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'. Since the overall probability of winning the prize is fixed, sabotage indirectly improves one's likelihood of winning the prize. However, this type of behavior is often out of norm, illegal, and costly – making sabotage an expensive strategy. Despite this, occurrence of such behavior is widespread, as the following examples indicate:

[1] In this context, Veblen (1921, pp 38) defines sabotage as the "conscientious withdrawal of efficiency."

- The steady decline of Microsoft since 2000 under CEO Steve Ballmer is often attributed 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, it is reported that people responsible for features will openly sabotage other people's efforts. A subtle way to accomplish this is by withholding information from colleagues to ensure that they do not get ahead on the rankings.

- Businesspeople often resort to costly strategies that are employed with the purpose of damaging the competitors' business. Friedman (1998, pp 577) describes such a business malpractice that used to occur in the 1890s. John H. Patterson, the owner of the National Cash Register Company, placed look-alike copies of the competitors' cash registers in the market. He mentioned that "The intention ... is not to sell it, but only to prevent the sales (of others)". He also fielded a special type of salaried counter-productive salesmen. Salesmen were not required to promote the 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 many marketing campaigns firms highlight their rival's weak points. One such example is the famous 2008 campaign by Progresso, which highlighted that its rival Campbell's has 95 soups made with the MSG.

This led to a 4%-5% decline in Campbell's soup sales in the USA (Lubin, 2011).

- This is even more frequent in political campaigns in which the opponents are discredited and often denigrated. In the 1997 general election campaign, the conservative party in the UK used an advertisement with a picture of the then Labor party leader Tony Blair. However, his eyes in the picture were replaced with demonic eyes.

- Political imprisonment can be seen as an extreme form of employment of such negative effort in a political contest. 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.

- *Scorched earth policy* is a famous strategy in warfare and takeover battles. In warfare, it involves troops burning any land/crops/trees as they retreat so there are no supplies to refresh the advancing army. In takeover battles, the strategy describes actions that a firm undertakes to make the proposed takeover unattractive to the acquiring firm, such a liquidating its valuable and desired assets and assuming liabilities.

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

All these examples, although in very different contexts, portray essen-

tially the same issue. However, since these examples often resemble other seemingly similar behaviors in contests, it is important to distinguish the act of sabotage in contests from behaviors such as 'punishment' (Abbink et al., 2010), 'cheating' (Preston and Szymanski, 2003), 'nastiness' (Abbink and Sadrieh, 2009) and 'risk taking' (Genakos and Pagliero, 2012). When an agent punishes someone, this typically happens either for not following a norm or due to fairness issues. Unlike sabotage, oftentimes the punishment is not executed in expectation of a material benefit to the punisher. An agent involved in cheating does so to illegally improve his own performance in a contest.[2] Instead, when engaging in sabotage, the same agent tries to illegally damage the performance of his rivals. Agents who possess features of nastiness – as in the joy of destruction or in the money burning games – may execute similar types of strategies as a saboteur would. But, although there might be intrinsic motivation for being nasty, employing the strategy does not necessarily entail a material benefit to the agent; instead sabotage behavior is motivated by the expected material benefit through the possible incremental probability of winning. Similarly, an agent's risky behavior may or may not involve other agents, especially competitors. Although engaging in sabotage behavior itself might be risky, to employ sabotage there needs to be a victim of sabotage - which is not a pre-condition for risky behavior.

Since the act of sabotage is common as well as distinguished, a stream of research investigated the mechanism and consequences of sabotage. However,

[2] A contestant intentionally reduces his performance in a form of cheating in sports called 'match fixing'. Preston and Szymanski (2003) analyze several forms of cheating in sports and mention that sabotage can be treated as cheating, but other cheating activities, such as doping and match-fixing, are not sabotage.

there exists no comprehensive survey to cover the existing studies. Partial reviews of sabotage behavior, as parts of larger reviews, were previously provided by Konrad (2009, Chapter 5.3) on theoretical literature and by Dechenaux et al. (2012, Chapter 6.1) on experimental literature. In addition, a brief overview on sabotage in rent-seeking contests was recently given by Amegashie (2013). In this study, we specifically review the economics literature of sabotage in contests, both in theoretical and applied sides. We cover the literature involving economic arguments, but do not consider literature from other interest areas, such as organizational behavior or political science although 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. There are mainly two ways to discourage a saboteur, either by reducing the benefit of sabotage or by increasing the costs of sabotage. We discuss these issues in detail and introduce examples. We conclude by pointing out the possible research contributions that are yet to be made.

2 Contests without sabotage

From a game-theory perspective, majority of contests are two-stage games. In the first stage, the contest organizer sets the 'rules of the game' such as structure of prizes, number of contestants and so on.[3] The contestants

[3]In some applications, such as war, there is no contest designer. In some other cases, these variables are beyond the control of the contest organizer. When parties lobby for a

observe these rules and choose their competitive activities in the game's second stage. The early contest literature (e.g., Tullock, 1980 in rent-seeking; Lazear and Rosen, 1981 in tournament; and Baye et al., 1996 in all-pay auction) has assumed that competitive actions are one-dimensional and affect own 'output' or 'performance' in the contest positively. The allocation of prizes among contestants depends upon all the contestants' performances and, hence, on the contestants' actions. Typically, a better performance makes a contestant more likely to receive a higher 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 winner prize that is valued w_{1i} by contestant i, and $N-1$ identical (and lower valued) loser prizes that are valued w_{2i} by contestant i. We define the prize spread as $\Delta w_i := w_{1i} - w_{2i}$. Contestant i receives the winner prize with probability $p_i = p_i(\boldsymbol{e})$, where $\boldsymbol{e} = (e_1, ..., e_N)$ denotes the vector of efforts. p_i, often termed as a 'contest success function' in the literature, 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 in order to maximize his expected payoff

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

with $c_i(e_i)$ as the cost of his action. A higher action is assumed to lead to higher cost, thus $c_i' > 0$.

government license, for instance, the winner prize is the profit that the parties can earn on being awarded the license. In both these situations, the game consists of only one (namely, the second) stage.

In major part of the applications, it is assumed that there is no between-contestant asymmetry in prize valuations, i.e., $w_{1i} = w_1 \forall i$ and $w_{2i} = w_2 \forall i$; and, as a result, $\Delta w_i = \Delta w$. For most part of the continuation, we will assume the same, making notes in case of exceptions.

From (1), it is easy to see that a contestant faces a simple trade-off when deciding about his optimal effort. By employing a higher level of effort, he can increase his probability of receiving the winner prize. However, he also increases the cost entailed by 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 prizes. So he may wish to design the contest in a way such 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 increasing the own performance (e.g. by choosing higher 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 $\boldsymbol{s}_i = (s_{i1}, ..., s_{ii-1}, s_{ii+1}, ..., s_{iN})$ being the actions that are aimed at decreasing the opponents' performances. In turn, the probabil-

ity of receiving the winner prize would have to be restated as $p_i(\boldsymbol{e}, \boldsymbol{s})$, with $\boldsymbol{s} = (\boldsymbol{s}_1, ..., \boldsymbol{s}_N)$.[4] 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) were the first economists to account for such destructive behavior in contests. They have denoted the actions s_{ij} $(j = 1, ..., N,\ j \neq i)$ as sabotage. Again, it is typically assumed that peforming these actions is costly. Among other components, these costs may contain a punishment for detected sabotage, cost to hide sabotage acts, and effort expended in implementing sabotage. So the total costs now amount to $c_i = c_i(e_i, \boldsymbol{s}_i)$.[5] Taking these arguments into account, the payoff function in (1), specified in the preceding section, changes to

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

While deciding upon his sabotage activities, a player faces a similar trade-off as the one described for productive efforts. By sabotaging his opponents, the player may increase not only his probability of winning, but also the cost entailed by his sabotage activities. Therefore, the theoretical prediction is that players may well find it in their interest to sabotage others.[6] Whether

[4] 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.

[5] An exception is the paper by Beviá and Corchón (2006). 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 decreases. Hence, there is an indirect rather than a direct cost of sabotage.

[6] In addition, it is easy to see that contestants are more inclined to sabotage others if

players behave in line with this prediction can only be answered by looking at the data on behavior in contests. Unfortunately, sabotage activities are rarely recorded so that field studies on sabotage are basically 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 compensation depends on relative performance. As sabotage can be understood as the opposite of help (because sabotage decreases 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, 2013; and Deutscher et al., 2013) that have been conducted to investigate sabotage in contests.

4 Welfare effects of sabotage

The examples stated in the Introduction offer anecdotal evidences of sabotage, and the studies cited in the previous section establish that sabotage is empirically relevant as well. These beg for investigating the welfare effects of sabotage. The act of sabotage has several consequences; but in general, it results in affecting the welfare adversely. It is easy to observe that the resources expended on sabotage behavior are unproductive and hence wasteful.

the probability of winning the prize is very sensitive to sabotage efforts. We revisit this issue when we discuss policies to restrict sabotage in Section 5.1.

Also, by definition, sabotage activities are aimed at reducing the rivals' productive performances thereby destroying valuable output in a system. 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 entails a discouragement effect on the players to put forth productive effort. In extreme cases, it may lead to an adverse selection of contestants in the sense that the best possible participants might altogether abstain from participation due to the occurrence of sabotage. To have a better understanding of these issues, in Subsection 4.1, we first determine who suffers the most from sabotage and consequently investigate the effects sabotage has on welfare. Then we consider several other perspectives of the effects of sabotage. Sabotage may restrict the contest organizer to either allow proper information flow, or to employ affirmative action policies. Agents involved in the system, who do not actively participate in the contest, such as spectators in sports or voters in an electoral contest might also be adversely affected if sabotage is present. We discuss such issues in Subsection 4.2.

4.1 Victims of sabotage and related consequences

Many studies on 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 decrease one player's output more strongly than another one's. In those circumstances, the obvious question that arises

is: Which player is subject to most sabotage?

One obvious aspect of this question is the possibility of heterogeneity among contestants. A contestant would be indifferent to sabotaging different rivals if they are homogenous. Heterogeneity may either have the nature of ex-ante, i.e., contestants may be inherently different in terms of efficiency, or it may have the nature of 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 be easily 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 in order to eliminate him early from the contest. A similar logic has been proven to be true in more general kinds of contests. In contests with at least three players, very able players are often sabotaged more strongly because they present the greater danger.[7]

To capture this argument formally, we put some additional structure on p_i. Suppose that each contestant's performance is denoted by y_i and suppose that y_i is a function of e_i and $\boldsymbol{s}_{-i}$. Assume further that contestant i receives the winner prize if and only if his performance is the high-

[7] 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 the bowers that are artificially decorated with exaggerate number of berries are subject to more destruction (Madden, 2001).

est among all the contestants' performances. 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 he will be the best performer among all of i's opponents or, in other words, that $\max\left\{y_1, ..., y_{i-1}, y_{i+1}, ..., y_N\right\} = y_j$. Then p_i simplifies to $p_i = P\left(y_i > y_j\right)$, and i finds it optimal to only sabotage contestant j (since $\frac{\partial p_i(\boldsymbol{e}^*, \boldsymbol{s}^*)}{\partial s_{ik}} = 0$ for all $k = 1, ..., N, k \neq i, j$), if he wants to sabotage anyone at all.[8]

The consequences for the contest organizer can be disastrous. Talented players may not want to participate in the contest if they anticipate sabotage (Münster 2007). The contest organizer may thus be stuck with mediocre contestants. This kind 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 highest effort is usually related with a better quality product or process, and the act of sabotage may potentially damage the quality.

Another consequence of the threat of sabotage is that, in early rounds of dynamic contests, players may not want to put forth much productive effort in order 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

[8] 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 lower ability.

psychologically on being sabotaged by others. Consequently, they may decide to help others in the early rounds of a dynamic tournament or even engage in self-sabotage in order to not 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 only hold 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 strongly than players that 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 et al. (2010). In the experiment by Carpenter et al. (2010), a competitor's performance is subjectively evaluated by his opponents. Players can sabotage other players by underreporting those players' performances. Carpenter et al. (2010) find that subjects indeed underreport 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 more strongly even in static two-player contests. The result depends on the assumption that the more able contestants have a higher return on productive effort, and productive and sabotage efforts are substitutes for each other.

Because of the first assumption, less able contestants exert lower productive effort, which together with the second assumption implies a higher choice of sabotage. Deutscher et al. test their predictions using data from German professional soccer and obtain results in line with their theoretical findings.[9] Vandegrift and Yavas (2010) conduct laboratory experiments studying two-person contests and find that better players are sabotaged more strongly.

However, theoretically it is also possible that the best players are not sabotaged more strongly and the outlined problems do not occur. Gürtler and Münster (2010) show that players may want to sabotage weak players in early rounds of dynamic contests in order 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 have an effect on 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 there exist complementarities between efforts, this kind of sabotage strategy decreases the opponent team's output most effectively.

Balafoutas et al. (2012) and Dato and Nieken (2013) also investigate

[9] See also Ishida (2012) and Balafoutas et al. (2012). In a model with private abilities, Ishida (2012) finds that very able players signaling 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 (i.e. players with higher abilities) are sabotaged more often.

the personal characteristics of contestants who are likely to be sabotaged. Balafoutas et al. (2012) analyze the interaction of ability and gender in sabotage decisions in Judo World Championships. They find that sabotage is used more by players with lower world ranking and is used more against players with higher world ranking, but there was no significant difference in sabotage behavior by gender. Instead of studying the effect of ability on sabotage, Dato and Nieken (2013) specifically investigate whether gender differences exist in sabotage behavior. In a real-effort experiment, they observe that men sabotage their opponents more strongly than the women. In turn, in a mixed tournament between men and women, women are sabotaged more strongly than men. While men therefore win the tournament with a higher probability, they also incur higher sabotage costs. These two effects more or less even out, so that the expected payoffs are similar for men and women.

4.2 Other welfare effects of sabotage

In the previous subsection, we discussed the effects of sabotage on its victims. However, just the fear of sabotage may discourage the players from putting forth productive effort. It may also lead to affect third parties adversely. In this subsection, we discuss studies highlighting these consequences. Charness et al. (2013) run a between-subject laboratory experiment to understand the possible effect of sabotage in a situation in which subjects receive a fixed (i.e., performance independent) wage. In different treatments, the subjects are required to perform a real effort task. In one treatment, they were not given any feedback about their relative performance, whereas in another treatment, they were informed about the same. In an additional treatment

with feedback, they had the opportunity to expend resources to reduce the performance of other participants (and hence improve their relative ranking). It is found that although there is no incentive to exert any effort, subjects actually expend effort in all treatments. Providing feedback improves performance significantly. However, when the subjects have the opportunity to sabotage each other, the final performance becomes significantly lower than the one in the treatment with feedback but no sabotage. This happens for two reasons: first, the subjects' final outcome is reduced by sabotage, and second, anticipating the same, the subjects exert less effort. This experiment raises a specific adverse effect of sabotage, namely that that the benefit from information disclosure in the form of feedback may be wiped out if sabotage is present.

Affirmative actions such as providing handicap or head-start, are often employed in various contests to provide advantages to disadvantaged groups. In our notation, an affirmative action induces more randomness in the function $p_i(\boldsymbol{e}, \boldsymbol{s})$, thus allowing greater chance for a disadvantaged player to win and thereby inducing him to exert higher effort.[10] However, this may also result in a higher level of sabotage, offsetting any welfare gain from the affirmative action. Brown and Chowdhury (2013) consider this particular issue in which a contest designer utilizes policy tools in order to level the playing field for the contestants. They use data from the British Horse Racing Association in 2010. In a standard horse race, every horse is required to carry a

[10]It is observed in sports such as Golf (Brown, 2011) that a difference in efficiency might discourage low efficiency players so that the overall effort exerted in the contest may be low. To overcome this issue, contest designers often handicap the efficient players or give head-starts to the players with lower efficiency.

minimum amount of weight. In the case of handicap races that are designed to make the race more 'even' among the contestants, higher ranked horses carry more weights 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 to win. They then include the concept of sabotage in horse racing. Often a jockey intentionally bumps into another horse, makes rail in front of other horses, or makes his horse run in a dangerous way to reduce the likelihood of other horses winning. Specifying these incidences as sabotage, the authors find that a handicap not only makes the contest even, it also increases the likelihood of sabotage. Brown and Chowdhury (2013) conclude that handicap, head-start or any other affirmative action related policy tools that make the contest even in order to induce more effort, should be used with caution as they can initiate and escalate sabotage behavior.

It is also conceivable that sabotage affects agents involved in the system who do not actively participate in the contest. Sabotage is often argued to be not only illegal, but also unethical and immoral and hence has a broad negative externality to people not actively participating in the competition. Preston and Szymanski (2003) argue that since most sports examine relative performance, sabotage may be an effective way to outperform others, especially with a small number of players. However, even if sabotage reduces competitors' quality of performance and thus increases one's winning probability, it may also lower 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 sports match. A survey of spectators in the Judo world championship shows that an increase in 'fouls' reduced the spectators' utility obtained from a Judo match.

This effect is highly prominent in the case of electoral contests, in which it is possible for political parties to resort to counter-productive acts such as vote rigging, vote snatching, political violence etc. in order to gain power, or to prevent opponent voters from voting. In a political economy framework, Chaturvedi (2005) shows that the party with the lower level of political support will resort to more counter-productive acts. The general population and the voters, however, also suffer from such acts.

In a similar vein, it can be hypothesized that, negative campaigning in market or in elections may reduce the utility of the consumers and the voters. To date, there is no research study analyzing the effects of negative product advertising on consumer welfare. However, there are both theoretical and empirical studies on the effects of negative political campaigns on voters. Regarding the effect of negative campaign 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.

It is shown by Soubeyran (2009) that sabotage may affect voters negatively in an election, resulting in lower voter turnout in the election. 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 negative campaign on voter turnout depends on voter sensitivity to attack. More specifically, when voter sensitivity to attack increases, candidates attack more, but the relation between attack and voter turnout may be non-linear. Freedman and Goldstein (1999) present a novel method to estimate exposure to television campaign advertisements. They obtain data on the frequency of an advertisement being aired ("strategic decisions of campaigns") from the coded Campaign Media Analysis Group (CMAG), and on individual quantity of television viewing ("respondent viewing behavior") through individual exposure survey, and derive an estimate of advertisement exposure. They find that exposure to negative campaign advertisements does not depress voter turnout; instead, it appears to increase voters' probability of voting. General and inconclusive results hold when they use a different measure of individual perceptions of the tones of campaign advertisements.

5 Policies to restrict sabotage

In the preceding sections, we established the occurrence and the consequences of sabotage. However, a clear understanding of the same 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 fully understand these policies, it is helpful to take a closer look at the contestants' optimal sabotage activities. If we assume that there is an interior solution to the contestants' maximization problem 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 prize) equals the marginal cost. Hence, policies that are aimed at tackling the sabotage problem affect a contestant's decision by either reducing the marginal benefit from sabotaging the 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 decrease the difference between winner and loser prizes. If this difference is lowered, contestants have a lower incentive to win the contest. As a result, they are less willing to engage in costly sabotage.[11] Formally, with a decreasing prize spread, the left-hand-side (LHS) of condition (3) becomes lower and so must the right-hand-side (RHS), i.e. $\frac{\partial c_i\left(e_i^*, \boldsymbol{s}_i^*\right)}{\partial s_{ij}}$. 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,

[11] 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.

Drago and Turnbull (1991) propose not to organize 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 to motivate the players to put forth productive effort. A similar argument has been put forward by Bose et al. (2010). However, experimental results by Charness et al. (2013) 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 (2005), for example, analyze the effects of increasing 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 higher productive efforts (attackers), but also of higher 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 has increased after the change in the prize structure.

A similar analysis is conducted by Corral et al. (2010) with data from 1994-95 and 1995-96 seasons of Spanish First Division Football League. Again, the effects of the change in the winning team's league points from two to three on sabotage activities are investigated. As the reward increases, Corral et al. (2010) predict a rise in players' defensive efforts and thus a higher likelihood of a sending-off. They find that when reward points increase, teams in the winning position are more likely to sabotage and to have a player sent off

the pitch. Their results also suggest that when the goal difference in a match becomes larger, the likelihood of a sending-off is generally smaller.[12]

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 spread and sabotage levels. As a result, they increase 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 to reduce contestants' benefit 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 decreases that rival's output and, hence, the probability of outperforming that rival only. If the number of contestants gets higher, 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 among all other contestants. This is because player i increases all other players' (except j) winning-probabilities by sabotaging player j. Based on the literature on public goods, it is a known fact that the provision

[12] This implies that an increase in the ex-post efficiency difference reduces sabotage. This result is in line with the study by Brown and Chowdhury (2013), who find less sabotage in horse racing when ex-ante efficiency difference is high. Overall, these studies suggest more sabotage between contestants with similar (ex-ante or ex-post) efficiency.

of a public good decreases when more players participate in the good.

To present this argument formally, recall that in many situations it is assumed that contestant i receives the winner prize if and only if his performance is the highest among all contestants' performances 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 higher 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 strongly (i.e. when he increases s_{ij}), y_j is decreased and it becomes more 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 benefit to increasing e_i relative to increasing s_{ij} gets higher, the higher the number of contestants competing for the prize.

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 the marginal cost, they expend effort in a standard Tullock contest. The difference between this model and the majority of the literature is that the sabotage does not directly affect the effort of the rival; instead, it affects the performance by increasing the cost of employing the effort. His results confirm the idea that sabotage is less relevant in bigger 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 employ positive amounts of sabotage.

In spite of the importance of this theoretically robust argument, there is little evidence on the effects of the number of contestants on sabotage activities. Harbring and Irlenbusch (2008) find that tournament size does not affect sabotage levels. However, in their experiment, sabotage is directed not against a particular rival, but decreases the output of all opponents. Obviously, 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 layer of their firm's hierarchy. He shows that the firm may want to consider external candidates for the vacancy if the internal candidates perform too poorly. If external candidates are admitted, the return to productive effort compared to sabotage increases for the internal contestants. The reason is simple and 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 only be directed against internal competitors. Hence, if the firm considers external candidates for promotion, internal competitors substitute productive effort in place of sabotage. Formally, this argument could be substantiated by assuming 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 increase the (marginal) cost of sabotage, $\frac{\partial c_i\left(e_i^*, \boldsymbol{s}_i^*\right)}{\partial s_{ij}}$, is to increase punishment in case 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. Curry and Mongrain (2009) consider such a situation and investigate whether stripped prizes should be reawarded to other contestants. They demonstrate that reawarding prizes mitigates the sabotage problem. If prizes are reawarded, a contestant can expect to improve his relative ranking and to obtain a high prize by disqualification of other contestants whose sabotage activities have been detected. By engaging in sabotage himself, the contestant risks missing the opportunity to receive a high 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 to spatially separate contestants in order to make it more difficult for them to sabotage each other. Consider the example of a firm that organizes a contest to motivate the employees. Employees from different locations find it harder to affect their opponents' performances than employees working in the same building or office.

When the contest organizer is able to affect the field of contestants, he may choose to let only those players participate in the contest 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 have a lower cost of sabotage since sabotage decreases the probability of feeling deprived or envious (Kräkel, 2000; Grund and Sliwka, 2005). The contest organizer should thus admit only those players who do not suffer from relative deprivation or envy. Unfortunately, it is often dif-

ficult to observe the specific characteristics of a player. 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 these mechanisms are far from being perfect.

A field study on the effects of cost on sabotage is provided by Balafoutas et al. (2012). They use data from two consecutive Judo World Championships in 2007 and 2009 to analyze the effects of the cost structure on the employment of sabotage. They specify the productive activity (attacking strategies) and sabotage activity (defending strategies – that are often penalized) in Judo. A change in rule in Judo in the year of 2009 allowed the players to use 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 occurrence of sabotage. Hence, it is suggested that when it is possible to monitor sabotage and impose costs upon the same, a high cost should be implemented.

Laboratory experiments have found that contestants retaliate when being 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 kind of indirect additional cost of sabotage. Obviously, players must learn the identity of saboteurs in order to be able to retaliate upon them. The contest should therefore be transparent in the sense that decisions should be publicly observable. Moreover, players should meet each other more than once in order 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 in order to reduce the output that the contest organizer receives. This kind of behavior is observed by Harbring and Irlenbusch (2005). They find that sabotage levels are higher if the organizer himself sets low tournament prizes rather than these low prizes being exogenously given. Presumably, the psychological costs of sabotaging others are higher if the contestants have been treated well by the contest organizer than if they have not. An immediate consequence is that the organizer should be generous towards the contestants in order to prevent them from engaging in sabotage. Finally, experimental results from Bolle et al. (2013) show that if retaliation itself can be retaliated, then players might be engaged only in destructive behavior; i.e., retaliation against a saboteur might escalate the execution of destructive efforts spirally 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 decisions. Kräkel (2005) considers a model in which players decide to help or sabotage each other first and, after having observed these 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, high 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 since, contrary to the contestants, he suffers from the decrease in productive efforts.

5.3 Other policies

There are policies to restrict sabotage that do not fall in 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 there exist externalities, because of which a coalition's probability of winning depends on its size. If externalities are sufficiently high, an equilibrium subcoalition exists and overall sabotage goes down. 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 on sabotage, however, the most important policy may be the adoption of a restrictive information policy. Gürtler et al. (2013) argue that many of the outlined problems rely on the possibility of players observing each others' talents or previous performances. Hence, the contest organizer should try to keep this kind 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 at this particular player. As a result, incentives to put forth productive effort in early rounds of the contest are reinstalled. Using experimental data, Gürtler et al. (2013) find that this kind of restrictive information policy works in the sense that productive efforts in early rounds of dynamic contests increase. As shown by Charness et al. (2013), such a policy may not only lower sabotage per se, it may also solve the additional problem of discouragement of productive effort (Gürtler et al., 2013). Another way is to introduce new contestants with unknown ability.

As Chen (2003) argues, including contestants from outside of an organization may reduce the likelihood of sabotage.

Another possibility to tackle the problems described earlier is to change the prize structure. Suppose that there is a single loser prize, but $N-1$ winner 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). Obviously, 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 towards 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, promotion, war, rent-seeking etc., and there is a sizeable body of literature on this topic, there is no existing effort to review the literature yet. In this article, we review the economics literature of the act of sabotage in contests.

Both theoretical and applied studies agree on several points regarding sabotage. Sabotage is positively related with the prize value to be won and negatively with the cost related to the sabotage act. Usually, more efficient agents are affected more severely by a saboteur. There are instances in which collective sabotage acts may offset the gains from the productive acts. This is because sabotage not only has the direct effect of damaging welfare, but also

indirect effects of dis-incentivizing players from exerting productive effort, and negative externality to third parties. There are several ways to restrict sabotage acts, viz. to increase the cost of sabotage, concealing information regarding efficiency or performance, increasing the number of participants, keeping the contest asymmetric etc.

As indicated earlier, sabotage has been extensively studied in the context of promotional tournaments. Sabotage may be relevant even if firms do not use tournaments. In some situations, firms find it in their interest to offer wage contracts to their employees that depend on the employees' relative performances. Such wage contract may, for instance, be optimal if individual performances are positively correlated and employees are risk-averse so that 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 so that sabotage is obviously an issue. Even if workers collaborate in teams, sabotage may occur.[13]

There are some interesting and relevant areas in which investigations relating to sabotage are yet to be conducted. The theoretical literature still needs to explore the issues of sabotage in contests with multiple prizes, in supergames or in dynamic games. The literature involving contest design issues such as seeding, prize distribution, or entry does not include sabotage yet. This is also true for contests involving externality issues such as network, social preference, and identity. There are very few attempts to analyze sabotage in groups and in coalitions. More fundamentally, each and every

[13] See Auriol et al. (2002), Bose et al. (2010), and Kräkel and Müller (2012).

model involving sabotage assumes the overall probability of winning a prize to be fixed. However, in cases such as patent races, advertising, and some sporting events this does not need to be true.

Current empirical evidence of sabotage is mostly from laboratory experiments, and the literature itself is also quite restricted. Issues such as sabotage in multi-stage games, the interaction between risk and sabotage, sabotage and contest design are currently almost untouched. The body of field evidence regarding sabotage is not large and most of the evidence is from sports. It will be useful to explore the investigation in areas other than sports. As discussed earlier, the welfare effects of sabotage in market or political environments are still to be estimated. Most theoretical and applied researches on sabotage focus on the 'effects' of sabotage, or the 'material reason' of sabotage. But as the nature of the act itself is crucially behavioral, it is very important to observe the theory through the lens of behavioral economists (for an example see Mui, 1995). Finally, to date, there exist no field experiment on sabotage. Hence, there is a broad scope of extending the literature in this area.

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