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Heterogeneity, leveling the playing field, and affirmative action in contests

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Abstract

The heterogeneous abilities of players in various competitive contexts often lead to undesirable outcomes such as low effort provision, a lack of diversity, and inequality. A range of policies is implemented to mitigate such issues by enforcing competitive balance, that is, by leveling the playing field. Some of those policies, known as affirmative action (AA) policies, are practiced in ethical response to historical discrimination against particular social groups, and are also aimed at increasing competition. This survey summarizes the rapidly growing literature on contest theory regarding AA and other policies that level the playing field. Using a general theoretical structure, we outline the theoretical, experimental, and empirical research findings on contest outcomes under a multitude of policy mechanisms, and in doing so, we touch upon some of the common debates in the AA literature.

KEYWORDS

affirmative action, contest, heterogeneity, survey

JEL CLASSIFICATION

A31, C72, D74, D82

1 | INTRODUCTION

> "You do not take a person who, for years, has been hobbled by chains and liberate him, bring him up to the starting line of a race and then say, 'You are free to compete with all the others,' and still justly believe that you have been completely fair."
> Lyndon Johnson (36th President of the United States; Howard University, 1965)

Various situations around us are characterized by competition. Examples include sports, promotional tournaments, college admissions, competition for market shares, and grant applications. In many such competitions, however, the competitors possess heterogeneous abilities. This often leads to undesirable outcomes such as under-representation of a certain sector of the community (e.g., minorities or women) in certain occupations and organizations, dwindled representation of local firms when competing with multinational corporations, or sports becoming less interesting.

Several policies are implemented to address this issue by providing a "competitive balance" (or, as we more often refer to it in this study, by "leveling the playing field"). Such policies are frequently executed in sports and other areas of competition. For instance, high-ranking players are often handicapped in golf, and favorite horses carry extra weights in horse racing to make the competition more exciting. Alongside these examples, there are social policies driven by particular ethical concerns. In the United States, at public colleges, in-state students often pay lower tuition fees than out-of-state students, and college admission policies may include criteria favorable to the enrollment of minority students. It is the same for a British student versus a non-British student in U.K. universities. Gender quotas in political organizations are popular worldwide. In Argentina, for example, a quota is set within political parties for a minimum representation of women (Argentine Law 24,012 in 1991). In 2014, the European Commission committed to having at least 40% of management positions filled by women; this target was achieved before the end of Jean-Claude Juncker's mandate in 2019 (European Commission, 2019).[1] Such gender quotas are also implemented in India. In addition, a certain percentage of government jobs (and promotional opportunities) in India are reserved for people of the scheduled castes and tribes. The Australian Government provides financial support for primary and secondary education, as well as for post-school qualifications and job facilities, specifically to the Aboriginal and Torres Strait Islanders. Although the main objectives are different, the tools employed in each of the above situations essentially aim at leveling the playing field in a competition.

A fair share of the policy examples given above can be categorized as "Affirmative Action" policies. Affirmative Action (AA hereinafter) is a set of ethically driven policies aimed at providing special opportunities to a historically disadvantaged group in order to enable the members of this group to compete with their more privileged peers.[2] AA policies "can be distinguished from other anti-discrimination measures by requiring pro-active steps (hence the phrase *affirmative*) to gradually eliminate differences between women and men, minorities and non-minorities, and so forth." (Holzer & Neumark, 2000, p. 484). Such policies are also known as equal

[1]See Piatti-Crocker (2019) for political quotas for women in Latin America, Bauer and Britton (2006) for policies in Africa, Krook et al. (2009) for policies in Western Europe, North America, Australia, and New Zealand, and other recent studies such as Hughes et al. (2019) and Hughes and Paxton (2019) for global and historical perspectives.

[2]Several sources such as the Cambridge dictionary, Encyclopaedia Britannica, and the Stanford Encyclopedia of Philosophy define AA as an active effort taken by public or private organizations to improve education or employment opportunities for women and minority groups. Our focus throughout will be on the *leveling the playing field* aspect.

opportunities (Canada), reservation (India and Nepal), positive action (United Kingdom), and so on.

Most competitive environments emerging in the socio-economic contexts discussed above can be modeled in economics as contests. Contests refer to a class of games in which players spend irretrievable and costly resources to secure valuable ends, and the probability of individual success is an increasing function of one's own expenditure relative to the spending of other players.[3] As will be argued later, heterogeneity among players can cause incentive problems in contests, and the economic importance (on top of the ethical importance) of AA comes from mitigating such incentive problems by leveling the playing field. Many relevant contest models assume there is a contest designer whose objective is to maximize total effort from the players.[4] Going with this convention, we limit our discussion to contests that have a designer who chooses the appropriate design elements at the beginning and maximizes total effort in the contest (unless otherwise specified).[5] We then summarize the theoretical and empirical findings from studies that discuss different mechanisms used to establish competitive balance (including AA) within such a framework.

1.1 | Brief history of the debate around AA

Traces of AA policy can be found in the Bible. Christians pursue laws derived from Scripture by individual achievements and, according to these relative achievements, they may enter heaven in a way that might contradict their social and economic status ("Many of you who are first will be last, and many who are last will be first"—Matthew 19:30). This is further exemplified by the parable of the laborers in the vineyard (Matthew 20:1–16) where a landowner hires laborers at different times on the same day according to their descending ability. At the end of the day, he decides to reward all laborers with the same amount: a denarius. Moreover, those who were hired last were the first to be paid.

The administrative provision of additional privileges for marginalized classes has been practiced in India since the beginning of the 20th century,[6] although the term "affirmative action" became popular with an executive order issued by U.S. President John F. Kennedy in 1961. After Lyndon Johnson's executive order of 1965, the earliest implementations of AA in the United States had mostly taken the form of quotas for African-Americans. Racial quotas attempt to correct past discrimination via the means of present discrimination. This fact was soon pointed out by two cases of white applicants claiming exclusion based on racial

[3]For the sake of terminological consistency, hereinafter, we will refer to any resource expenditure as "effort."

[4]Real-world contests may often have no designer (e.g., war), or a designer with alternative objectives (e.g., the recruiters in a job market aim to find the best deserving candidate).

[5]The social desirability of maximizing total effort depends on the context. For example, when efforts are linked to corruption, harmful usage or wastage of resources, the social desirability of maximizing total effort is highly questionable. However, in the context of AA, efforts are usually linked to desirable social outcomes such as more study time in different social groups, a harder fight in a competitive sport, higher commitment in job seeking, or quality and diversity of proposals for a project.

[6]Shahuji, the first Maharaja of the princely state of Kolhapur, provided educational and employment support for the marginalized sector of society as early as 1902. Beginning with the Government of India Act of 1909, a few other reforms in British India ensured political representation of religious and social minorities. Educational quotas for scheduled castes and tribes in independent India were introduced in 1954.

discrimination, which is prohibited under the Civil Rights Act (1974, Louisiana; and 1978, California).[7] One of the arguments against AA policies is therefore related to the non-equal treatment of individuals. These policies, sometimes called discrimination policies, give preferential treatment to preferred groups, causing reverse discrimination against non-preferred groups. Other criticisms of AA are mostly linked to the potentially negative impact of these policies on economic efficiency; for instance, the decrements in standards and overall effort levels of students, mismatches between skilled workers and jobs, or a negative financial cost–benefit outcome (see Fryer Jr & Loury, 2005; Holzer & Neumark, 2000; Sowell, 2004). Nonetheless, AA has been defended on efficiency grounds as well. Loury (1981) highlights that there is a market failure with equally skilled workers being paid unequally, and the intervention via equal opportunities is not enough to eliminate the persistence of economic disparities, especially when the population is segregated by income and race. Niederle et al. (2013) demonstrate that while high-performing women may fail to enter competitions, this sub-optimal decision can be corrected by AA without lowering the requirements to win. Moreover, AA can counteract other discriminatory actions against minority groups that also harm economic efficiency, such as in the case of racial discrimination in admitting applicants to the Yale School of Medicine in 1935,[8] or the more recent case of a Japanese medical university that lowered the entrance results for female applicants (The Guardian, 2018).

Gamson and Modigliani (1994) present a precise account of the framing of AA in different public commentaries in the United States between 1965 and 1985 and corresponding interpretations by popular media. The major arguments against AA, as they point out, relate to reverse discrimination, undeserving advantages, artificial divisions, and hurting minority sentiments through sympathizing. They also classify associated policy stands, such as remedial action, striking a delicate balance, and non-preferential treatment. Based on the empirical findings from two standardized tests used for college admissions in the United States (the SAT and LSAT), Sturm and Guinier (1996) examine an assessment of the policy debate over AA and advocate for the "delicate balance" principle regarding the role of conventional institutions in dealing with racial discrimination. Schuck (2014) also reviews this debate from a normative angle. Kiewiet (2015) exemplifies the controversy of the design of college admissions criteria with the case of the University of California, Los Angeles (UCLA), a university that tries to increase the admissions rate of under-represented minority students without breaking constitutional laws. Severe criticisms and complaints against AA have influenced some states in the United States to ban these policies in college admissions (Desilver, 2014).[9] In summary, society is divided between supporters and detractors of AA, and policymakers' interest is to implement these policies with the minimum possible compromise in terms of economic efficiency.

[7]See Fang and Moro (2011, pp. 163–164) for a more detailed account of the history of the legal provision of AA in the United States.

[8]In 1935, Yale accepted 76 applicants from a pool of 501. About 200 of these applicants were Jewish, and only five got in. The dean's instructions were remarkably precise: "Never admit more than five Jews, take only two Italian Catholics, and take no blacks at all" (Oshinsky, 2005, p. 98).

[9]Likewise, in the UK, AA policies that entail preferential treatment ("positive discrimination") are unlawful. However, other AA policies ("positive action") are allowed. Section 158 of the Equality Act of 2010 explains what is permitted: enabling or encouraging persons who share a protected characteristic (age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, sex or sexual orientation) to overcome or minimize that disadvantage, meeting their unique needs, and enabling or encouraging their participation in activities.

1.2 | Related surveys and the scope of the present study

The literature on leveling the playing field and the debate around the same have been assessed from economic (Fang & Moro, 2011; Fryer Jr & Loury, 2005; Holzer & Neumark, 2000; Mealem & Nitzan, 2016), legal (Hyman et al., 2012; Schuck, 2014; Somani, 2013; Sturm & Guinier, 1996), psychological (Yang et al., 2006), and institutional (Kalev et al., 2006; Murrell & Jones, 1996; Sowell, 2004) perspectives, though most surveys in disciplines outside of economics focus exclusively on AA.

Murrell and Jones (1996) report existing statistical and literary findings on the impact of AA on employment, education, and business ownership. Then, Holzer and Neumark (2000) assess the effect of AA on performance in the labor market, education, and business procurement in the United States. They observe that weaker candidates not only derive immediate benefits from AA but also are often able to improve their subsequent performance as well. In an attempt to evaluate alternative policies for diversity management in U.S. corporate establishments between 1971 and 2002, Kalev et al. (2006) find that diversity training is useful only when managers are explicitly made responsible for diversity management. Hyman et al. (2012) review institutional attempts toward diversity management under the legislation of the EU, and Sowell (2004) analyzes the general impact of AA in India, Malaysia, Nigeria, Sri Lanka, and the United States.

Within the economics literature, Fang and Moro (2011) survey the major theoretical models that strive to explain different sources of persistent statistical discrimination, while Fryer Jr and Loury (2005) summarize economic questions and arguments about AA. Finally, Mealem and Nitzan (2016) review the theoretical literature on the different ways of leveling the playing field in contests (which they term "discrimination"). They focus exclusively on the scope of Tullock contests (Tullock, 1980) to compare and contrast the effects of leveling the playing field by (1) modifying players' valuations for a reward ("direct discrimination"); (2) adding extra effort to their incurred efforts ("head start"); (3) multiplying the incurred effort ("overt discrimination"); and (4) manipulating the intensity return to effort in the probability of winning ("covert discrimination").

In the present study, we consider the economics literature on policies (including AA) for leveling the playing field using contest models (including the ratio-form contest, all-pay auctions, and tournaments), keeping the legal, political, and institutional literature out of scope. Although we make relevant references to players' payoffs, our primary focus is on the designer's objectives. Our study is closest to Mealem and Nitzan (2016) in centering on the different tools that can be used to change competitors' incentives and induce desirable outcomes. However, our approach is more general and inclusive on different grounds: (i) we discuss theoretical, experimental, and empirical findings instead of focusing only on formal theoretical literature; (ii) we cover all the major mechanisms in the literature instead of four specific mechanisms; (iii) our discussion comprises of all three standard forms of contests, namely the ratio-form contest (the most popular form of which is the Tullock contest), all-pay auctions, and tournaments, instead of Tullock contests alone; and (iv) we consider an n-player setup instead of a 2-player contest wherever possible.

The primary purpose of this survey is to summarize what research on contests and tournaments has elaborated so far on the implications of AA and related mechanisms regarding competitive choices and outcomes, while being useful to researchers studying competitive balance in heterogeneous competitions with theoretical or empirical methods. We include literature that studies one of the following topics within a contest framework.

- Desirability of leveling the playing field.
- Effectiveness of one or more leveling mechanisms.
- Optimal choice of parameters or design elements given that the designer has a particular leveling objective or follows a specific leveling mechanism.

In addition, we mention experimental and empirical studies that do not use an explicitly theoretical framework around contests, but that strongly support or reject a major finding by another study within this framework.

The remainder of this paper is organized as follows. The next section provides the general theoretical structure relevant for subsequent discussion. Section 3 briefly addresses the implications of heterogeneity for the total effort outcome in a contest, and when or why leveling the playing field may be desirable. Section 4 considers different mechanisms for leveling the playing field, as well as theoretical and empirical evidence on how these mechanisms affect overall performance by modifying the incentive structures in different types of contests. Section 5 summarizes studies that report undesirable effects of leveling the playing field in contests, and Section 6 concludes the paper.

2 | THEORETICAL FRAMEWORK

Consider a contest with a set N of $n \geq 2$ risk-neutral players that exert costly effort to win a prize. Player $i \in N$ exerts effort $e_i \in [0, \overline{e_i}]$ to increase the probability p_i of winning the prize of value $v_i > 0$, where $\overline{e_i}$ is the player's budget or endowment. This budget can be finite or infinite, and a finite budget can be lower than, equal to, or higher than the prize value. The impact of a player's effort on the contest is determined by the impact function $f_i(\cdot)$, such that the final impact of e_i is $x_i = f_i(e_i)$. This distinction is especially critical in a contest with heterogeneous players, where the elements of $f_i(\cdot)$ can vary across players. Examples of three popular effort impact functions are described below.

- $x_i = \alpha_i e_i + \theta_i$ as in Gradstein (1995) and Runkel (2006b), where $\alpha_i \geq 0$ and θ_i are multiplicative and additive parameters, respectively, that determine realized effort. The multiplicative parameter α_i is often interpreted as the player's ability.
- $x_i = e_i^r$ as in Tullock (1980), where $r > 0$ measures the sensitivity of p_i to a player's effort. As r increases, the more sensitive the contest outcome is to a player's effort.
- $x_i = e_i + \varepsilon_i$ or $x_i = e_i \varepsilon_i$ as in Lazear and Rosen (1981), where ε_i is a random noise. This type of impact function gives a noisy prediction of a player's performance.

Conventionally, the impact vector of a contest is $\boldsymbol{x} = \{x_1, x_2, ..., x_n\}$ and vector $\boldsymbol{x_{-i}} = \{x_j: j \in N \setminus i\}$ contains the effort impacts of all the players except Player i. The mapping of these effort impacts into individual winning probabilities, $p_i(\boldsymbol{x}) : \mathbb{R}_+^n \to [0, 1]$, is called the contest success function (CSF). This function specifies the winning probability of Player i, which increases in own impact x_i, but decreases in any other player's impact $x_{j \in N \setminus i}$. Therefore, the CSF must satisfy the following properties: $\frac{\partial p_i}{\partial x_i} \geq 0$, $\frac{\partial p_i}{\partial x_{j \in N \setminus i}} \leq 0$, wherever differentiable, and $\sum p_i = 1$. Although a player's probability of winning increases with own effort, there is a trade-off due to effort being costly. The cost of effort is denoted by c_i.

In the majority of the literature, the CSF $p_i(\boldsymbol{x})$ takes one of three canonical forms: the ratio-form (Tullock, 1980), the all-pay auction (Baye et al., 1996; Hillman & Riley, 1989), or the tournament (Lazear & Rosen, 1981). The winning probability of Player i in a ratio-form contest is simply the ratio of own impact to the aggregate impact of all the players.

$$p_i^{\text{Ratio}}(\boldsymbol{x}) = \begin{cases} \dfrac{x_i}{\sum_{j\in N} x_j} & \text{if } \sum_{j\in N} x_j > 0 \\ \dfrac{1}{n} & \text{otherwise} \end{cases}. \tag{1}$$

The Tullock contest is obtained by inserting the effort impact function $x_i = e_i^r$ into the ratio-form CSF (1):

$$p_i^{\text{Tullock}}(\boldsymbol{x}) = \begin{cases} \dfrac{e_i^r}{\sum_{j\in N} e_j^r} & \text{if } \sum_{j\in N} e_j > 0 \\ \dfrac{1}{n} & \text{otherwise} \end{cases}. \tag{2}$$

Two popular special cases of this general Tullock CSF, also known as the power CSF, are the lottery, when $r = 1$, and the APA, when $r = \infty$ (Baye et al., 1994). The specific functional form of the CSF for the all-pay auction (APA) is given below.

$$p_i^{\text{APA}}(\boldsymbol{x}) = \begin{cases} 1 & \text{if } x_i > \max\{\boldsymbol{x_{-i}}\} \\ \dfrac{1}{k} & \text{if } x_i = \max\{\boldsymbol{x}\} \text{ and } k = |j\in N : x_j = \max\{\boldsymbol{x}\}| \\ 0 & \text{otherwise} \end{cases}. \tag{3}$$

Another popular form of CSF is the tournament (Lazear & Rosen, 1981), mentioned above. Players' efforts are not directly observable in this setting, but players produce a final output or score, $x_i = e_i + \varepsilon_i$, which the contest designer can observe. The precise form of a tournament CSF is

$$p_i^T(\boldsymbol{x}) = \prod_{j\in N\setminus i} \text{prob}(x_i > x_j) = \prod_{j\in N\setminus i} G(e_i - e_j), \tag{4}$$

where $G(\cdot)$ is the cumulative distribution function of $\xi = \varepsilon_j - \varepsilon_i$, and ε_i and ε_j are random noises with known distributions that have $E(\varepsilon_i) = E(\varepsilon_j) = 0$ and $E(\varepsilon_i^2) = E(\varepsilon_j^2) = \sigma^2$ for all $i, j \in N$. Therefore, $\xi \sim g(\xi)$, where $g(\cdot)$ is the probability distribution function for $G(\cdot)$, with $E(\xi) = 0$ and $E(\xi^2) = 2\sigma^2$. The tournament CSF is a special case of the APA when the impact function has the form $x_i = e_i + \varepsilon_i$. The APA provides a deterministic rule for deciding the contest winner, while the other two CSFs (tournament and ratio-form) are stochastic.

The cost of effort is modeled as a function $c_i = \gamma_i(e_i)$ where $\gamma_i(\cdot): \mathbb{R}_+ \to \mathbb{R}_+$. This function has the following properties: $\gamma_i(0) = 0$, $\gamma_i'(\cdot) > 0$, and it takes either a linear ($\gamma''(\cdot) = 0$) or convex ($\gamma''(\cdot) > 0$) form. Further assumptions on $\gamma_i'(0)$ are often imposed. Within this setting, a representative risk-neutral Player i maximizes the following expected utility,[10]

[10]In this model, CSF can be interpreted either as the probability of winning an indivisible prize when players are uncertain about the designer's selection criteria, or as a share of a divisible prize after competing; see Corchón and Dahm (2010) and Chowdhury et al. (2014). For normative justifications of the CSF, see Corchón (2007), Garfinkel and Skaperdas (2007), and Konrad (2009).

$$\mathrm{EU}_i = p_i(\boldsymbol{x})v_i - c_i = p_i(f_i(e_i), \boldsymbol{f}_{-\boldsymbol{i}}(\boldsymbol{e}_{-\boldsymbol{i}}))v_i - \gamma_i(e_i). \tag{5}$$

We use this general setting and notations to develop the theoretical arguments proposed in the relevant literature.[11] As stated earlier, we assume there is a contest designer who wants to maximize the total effort in the contest unless otherwise specified. The contest designer can modify the contest setting for achieving the relevant objective(s).[12] Whatever the reasons for modifications may be, we consider any artificial manipulation by the designer as "bias" in the contest (and hence, the corresponding act as biasing). We stick to the n-player model wherever possible. The usual implication of higher (lower) heterogeneity in an n-player model is a mean-preserving increase (decrease) in the variation of costs or valuations or effort impact. Most findings in the literature, however, are derived from a setting with two players. In all such cases, we assume that Player 1 is "stronger" than Player 2 due to his/her features or background, or because of historical privileges. The relative advantage of Player 1 can be modeled as higher effort impact ($x_1 > x_2$), higher prize valuation ($v_1 > v_2$), lower cost ($c_1 < c_2$), or through a combination of more than one of these elements. We consider complete information unless otherwise specified.

3 | PLAYER HETEROGENEITY AND THE NEED FOR COMPETITIVE BALANCE

There is a sizable discourse in the literature about the desirability of achieving competitive balance from the designer's perspective. We discuss the main propositions regarding the same using the theoretical framework described in Section 2. The equal opportunity approach to leveling the playing field (Roemer, 1998) suggests compensating players for their circumstantial differences such that success is substantially sensitive to effort, regardless of societal or environmental elements. A positive economic argument in favor of equal opportunity has to additionally consider if ensuring close competition can serve a designer's interest.

In sports contests, for example, the designer makes a gain from high audience interest. Audience interest increases with the expected intensity of the competition and the consequent uncertainty of the outcome. In an empirical study on major league baseball in the 1990s, Schmidt and Berri (2001) observe that competitive balance increased despite a widening gap between the rich and the poor teams, thereby improving audience attendance significantly. In a contest where the designer benefits from a close competition between players, Runkel (2006a) shows that increasing the strongest player's (or the favorite's) effort cost enhances closeness by reducing the gap in expected winning probabilities, but it also reduces total equilibrium performance. These policies may help the designer to increase aggregate effort especially when there is a lack of incentives to compete. As noted by Rottenberg (1956), "the nature of the industry is such that competitors must be of approximate equal size if any are to be successful." This is

[11]See Nitzan (1994), Corchón (2007), Konrad (2009), Vojnović (2015), Corchón and Serena (2018), and Fu and Wu (2019) for comprehensive accounts of the literature on contest theory.

[12]Drugov and Ryvkin (2017) and Serena (2017) discuss the most common objectives of the designer. Depending on the application context, the designer could be interested in maximizing aggregate effort (e.g., sports) or minimizing aggregate effort (e.g., an election). The designer could also be interested in maximizing the winner's effort (e.g., R&D), the players' expected utility (e.g., auctions), or the winning probability of the best candidate (e.g., recruitment).

because in contests with heterogeneous players, large enough gaps in players' abilities, prize valuations, effort costs, and/or endowments result in different expected payoffs for different players even when all players exert similar efforts, implying low effort incentives for the weaker players. Reduced effort from the weaker players dampen the stronger players' effort incentives when efforts are strategic complements; weaker players maximize their expected payoffs by lowering their efforts against stronger rivals, which in turn requires stronger players to best respond with reduced effort levels. Thus, due to an exogenous increase in heterogeneity, both players end up choosing lower effort in the equilibrium; this is commonly called the "discouragement effect."

Drugov and Ryvkin (2022) argue that whether a discouragement effect arises due to increased heterogeneity depends on the type of heterogeneity and how the heterogeneity is introduced. In particular, they assert that when the heterogeneous component enters the payoff function in a relative format (e.g., different abilities in a Tullock CSF), higher heterogeneity either increases or decreases aggregate effort, but the effect (in whichever direction it may be) is monotonic. In contrast, when the heterogeneous component enters the payoff function in an absolute form (e.g., different prize valuations or different marginal costs), either the encouragement or discouragement effect can be induced through an appropriately stylized introduction of higher heterogeneity. To this end, as we discuss below in Sections 3.1 and 3.2, whether heterogeneity among players triggers the discouragement effect and thereby causes lower total effort is debatable.

3.1 | Arguments for leveling the playing field

An array of empirical studies examine the role and importance of competitive balance. Many concentrate on sports, and their findings substantially support the argument on the discouragement effect. For example, Sunde (2009) shows that, under increasing heterogeneity, weaker players (underdogs) in tennis tournaments are more affected by the discouragement effect. In professional golf tournaments, Brown (2011) finds that the average score of players falls in the presence of a superstar like Tiger Woods. In amateur golf tournaments, Franke (2012b) finds that leveling the playing field has a positive impact on performance. Similar outcomes are found in horse racing, where handicapping favorite horses leads to an increase in the likelihood of the other horses winning (Brown & Chowdhury, 2017).

- *Simultaneous contests with heterogeneous players*: A handful of studies (Baik, 1994; Cornes & Hartley, 2005; Nitzan, 1994; Stein, 2002) have theoretically shown that, in the presence of linear costs, aggregate effort in a ratio-form contest (both the lottery and the general Tullock CSF) falls due to the discouragement effect from increased heterogeneity. Most of these studies (except Stein, 2002) model heterogeneity in terms of effort impact. Weaker players have lower odds of winning due to lower impact, which in turn may reduce their incentive to exert more effort. For favorites, on the other hand, higher impact translates into higher winning probability for a given effort level, thereby resulting in lower effort incentives. Consequently, both players spend lower effort in the equilibrium compared to a perfectly leveled contest. Clark and Riis (2000) also indicate that it is in the interest of an effort-maximizing designer to even up the contest when heterogeneous players compete in an all-pay contest with nonlinear costs. The discouragement effect has also been studied using laboratory experiments (for a survey on contest experiments, see Dechenaux et al., 2015). A within-subject experiment in Hart et al. (2015) examines two sources of heterogeneity: budget and prize valuations. They do not find total effort to be statistically different between the homogeneous treatment and the treatment with heterogeneous prize valuations. However, introducing heterogeneous budgets reduces total effort compared to the homogeneous case. March and Sahm (2017) uncover evidence supporting the discouragement effect in the laboratory, although this effect is not statistically significant for strong players. The authors explain this outcome using the concept of disappointment aversion. Players experience lower utilities if they receive a payoff lower than the expected one. At moderate levels of heterogeneity and high prize value, the discouragement effect from heterogeneity and the positive incentive due to anticipated disappointment from losing cancel each other out for strong players so that their final effort does not differ from the symmetric case. For weaker players, the discouragement effect lowers effort for high prize value, and the authors suggest the designer not inform players about large levels of heterogeneity.

- *Dynamic contests with homogeneous players*: Another way the discouragement effect can arise is when players who were initially homogeneous become heterogeneous at a later point in a dynamic contest. This is because initial success can put one player in an advantageous position, which then persists throughout the contest. The literature on dynamic patent races is relevant in this context (see Budd et al., 1993; Grossman & Shapiro, 1985; Harris & Vickers, 1985, 1987). Each player invests effort in each period and the one to reach the finishing line first is the winner. Harris and Vickers (1985) show that the players' prize valuations and effort impacts relative to their distances from the finishing line determine the nature of the competition at any given point in time. In particular, these parameter values jointly define ranges in which one of the two players enjoys an absolute strategic advantage and the other drops out, and ranges where both players lack competitive incentives. With a large enough lead, the leading player's effort incentive is high enough to preempt the opponent. Both Grossman and Shapiro (1985) and Harris and Vickers (1987) indicate that the leading player exerts greater effort compared to the lagging player, and efforts increase as the gap between the players shrinks. Klumpp and Polborn (2006) and Konrad and Kovenock (2009) consider the discouragement effect in a sequence of simultaneous-move component contests where success requires a player to win a target number of these component contests before the other players meet their targets. Using a Tullock CSF, Klumpp and Polborn (2006) demonstrate that success in the first component contest increases the continuation value for the winner, thereby creating asymmetric incentives in subsequent contests (the "New Hampshire effect"). Consequently, the first component contest is the most effort intensive. In an APA framework, however, the component contest—which gives an absolute advantage to the respective winner (so that he/she can win the remaining contests with no effort)—can occur later in the sequence (Konrad & Kovenock, 2009).

  If the discouragement effect is strong enough, it can even rationalize artificially biasing an initially homogeneous contest to solve incentive problems arising out of such subsequent heterogeneity. Using an organizational context, Meyer (1992) argues that biasing the final contest (promotion) in favor of the first-period winner can maximize total effort by encouraging effort in the first contest (interim competition). This is because, even when the players are ex-ante symmetric, favoring the first-period loser lowers incentives in the first period (ratcheting), while favoring the first-period winner lowers incentives in the second period (moral hazard). Accordingly, the optimal bias has a lower and upper bound; the lower bound ensures that there is enough competition in the first period, and the upper bound mitigates the discouragement effect on the first period loser in the second period. Denter and Sisak (2016) reveal that, in a two-stage contest with homogeneous players, a biased CSF increases the highest effort without reducing aggregate effort. In a best-of-three contest, Barbieri and Serena (2018) suggest biasing earlier contests to mitigate the incentive problem in the third contest when there might be a clear winner.[13] Malueg and Yates (2010) uses data from professional tennis matches to show that strategic adjustments in the effort by players result in equal winning probabilities by the third round, thus supporting the theoretical predictions for dynamic best-of-three contests.

3.2 | Arguments against completely leveling the playing field

In contrast to the above arguments in favor of leveling the playing field, there is also substantial theoretical and empirical evidence implying that some heterogeneity can be desirable in a contest. Numerous scenarios exist in which a biased contest can be efficient, even when the players are ex-ante symmetric. Drugov and Ryvkin (2017) argue that the overall role of bias in a contest is to equalize the marginal benefit of effort across players. They provide a novel classification of different types of biased CSFs and a general framework for analyzing several possible objectives of the contest designer. A few specific instances of when heterogeneity can be beneficial for achieving the designer's objective, as discussed in related literature, are listed below.

- *The designer maximizes total effort*: In an n-player contest where individuals face a symmetric lottery CSF and non-linear effort costs, Ryvkin (2013) shows that heterogeneity, in terms of prize valuation (or a multiplicative cost parameter), has a positive effect on aggregate effort when effort costs are relatively flat,[14] and a negative effect on aggregate effort when effort costs are very steep. These findings are robust under both complete and incomplete information. Moreover, Ryvkin (2013, footnote 9) argues that reformulating the model structures of Stein (2002) and Cornes and Hartley (2005) to accommodate heterogeneous costs yields similar results. Gürtler and Gürtler (2015) examine across-firm hiring contests where external employers base their assessments and wage offers on the observed career paths of the candidates, and the marginal gain from a promotion is higher for a low-ability candidate. A moderate level of heterogeneity increases total effort by enhancing the effort incentives for low-ability players in such a setting. Bastani et al. (2022) indicate that the discouragement effect does not always hold when there is uncertainty about players' skill distribution. When players are not fully aware of their own skills or those of other players, increasing heterogeneity by manipulating the skill distribution can drive higher individual effort. In addition, when players are expected to have similar skills, the contest designer can enhance effort by increasing uncertainty.
- *The designer maximizes the highest effort*: A moderate level of heterogeneity may be desirable in a contest where the designer's objective is to maximize the highest individual effort or to choose the player with the highest ability as the winner. In a complete information environment, Seel and Wasser (2014) demonstrate that a moderate level of heterogeneity is desirable for a designer who maximizes a weighted sum of the expected highest effort and the expected average effort. If the designer lacks information about the players' types and one of his/her

[13] For elimination contests, see Cohen et al. (2018) and Fu and Wu (2018).

[14] The support in Section 4.4 explains the equivalence between heterogeneity in terms of prize valuations and costs.

objectives is to choose the player with the highest ability, then introducing asymmetry into the contest may be optimal. Cohen et al. (2008) consider a setup in which the players' types are private information and the value of winning depends on the corresponding player's type, as well as the actual reward-value, which is effort-dependent. Due to the effort costs being strictly increasing in effort and strictly decreasing in player-type, the effort-dependent rewards can be considered a tool to preserve heterogeneity. In a static APA where both abilities and efforts are privately observable to players, Pérez-Castrillo and Wettstein (2016) claim that a discriminatory contest (a contest where the prize value depends on the winner's identity) strictly dominates a non-discriminatory one when the players' abilities exhibit a concave distribution and the contest designer's objective is to select the high type player. In fact, they invoke a discriminatory contest, even when players are similar, to begin with. Kawamura and de Barreda (2014) obtain the same outcome when players know their own as well as each other's types, but the designer does not know the players' types.

In a lab experiment, Fallucchi et al. (2021) explore the impact of heterogeneity stemming from different sources (budget, abilities, prize valuation) on total effort. They design the experiment as a two-player lottery with complete information where the different sources of heterogeneity should have a similar impact on the aggregate effort. However, they find that the treatment with heterogeneous abilities brings the maximum aggregate effort even higher than the symmetric treatment. Moreover, the stronger players exert similar efforts in all the heterogeneous and homogeneous conditions, while the weaker players exert higher (lower) effort in the heterogeneous ability (heterogeneous budget or valuation) condition in comparison to the homogeneous condition.

Overall, there are mixed findings on the impact of heterogeneity on players' incentives to compete. The next section describes different mechanisms to level the playing field and investigates whether each mechanism can enhance the aggregate effort.

4 | MECHANISMS FOR LEVELING THE PLAYING FIELD IN CONTESTS

Policies to achieve higher competitive balance in a contest can be motivated by revenue concerns, ethical concerns, or both. AA policies, for example, aim to increase diversity in competitive outcomes. This can be measured by the diversity among the winners or active players. Policymakers manipulate the contest setting to increase the winning probability of players who belong to a disadvantaged group. Policies aimed at leveling the playing field may reduce the cost differences by increasing (decreasing) advantaged (disadvantaged) players' marginal effort costs, or balance the gap in success probabilities by attaching higher weights to the efforts of disadvantaged players. Leveling the playing field by introducing bias into the effort impact functions or by modifying the effort cost functions is commonly referred to as "handicaps" and "head starts." The term "handicap" originates from a game called *hand in cap*, played in 17th-century Britain, where a neutral umpire would determine the odds in an unequal contest between two bettors. By the middle of the 18th century, the term was used in the context of a horse race where an umpire decided the weight to be carried by each horse in order to equalize the chances between superior and inferior horses. A "handicap" policy in a contest could be any sort of manipulation that curbs the favorite's incentives by reducing his/her expected payoff. A "head start," on the other hand, usually refers to a policy of directly favoring the a priori disadvantaged player. This convention contains a historical reference to the early childhood support program launched by the U.S. Department of Health and Human Services in 1965. The term "handicap" therefore has a negative connotation, while the term "head start" has a positive one. However, there is no distinction between "handicap" and "head start" from a modeling point of view as both policies arguably have the same effect on the incentive structure, ceteris paribus. We return to this point later while discussing the experimental results.

In a generalized framework, a contest designer can theoretically introduce various biases to influence the competitive outcome in order to enhance total effort to achieve competitive balance, or to increase the efficiency of the contest mechanism by achieving the designer's objective at minimum cost. However, any such actions will affect all players by modifying the overall incentive structure of the game. Given a player's payoff function (5), different mechanisms commonly implemented to level the playing field include the following:

1. The choice of the CSF (p_i).
2. Biasing the contest through the effort impact function (f_i).
3. The choice of the reward valuation (v_i) and cost of effort (γ_i).
4. Modifying the reward structure (changing either p_i or v_i, or both).
5. Introducing caps on effort (limiting $\overline{e_i}$).
6. Miscellaneous mechanisms.

In the following, we classify the existing contest literature based on the different mechanisms listed above, and discuss the major findings on optimal contest design under heterogeneity. In the context of this survey, optimality refers to total effort maximization by the contest designer unless otherwise stated. For each mechanism, we summarize the overall findings in one or more "observations."[15]

4.1 | Mechanism 1: Choice of the CSF

The choice of the CSF (p_i in Equation (5)) has been widely researched in the literature. The general Tullock CSF (Equation (2)) offers full flexibility in terms of how sensitive the contest outcome is to individual effort outlays. As r increases, the contest outcome becomes increasingly sensitive to discrepancies in individual effort. The parameter r is often interpreted as the returns to scale from effort (Baye et al., 1994; Nti, 1999; Perez-Castrillo & Verdier, 1992): $r > 1$ indicating increasing returns and $r < 1$ denoting decreasing returns. Alternatively, r is interpreted as the noise in the CSF (Amegashie, 2006; Balart et al., 2017; Jia, 2008) and this is the interpretation we follow. Setting $r = 0$ implies that the contest outcome is completely random and independent of individual effort levels; when $r = 1$, the contest takes the form of a raffle or lottery (L), and when $r = \infty$, it characterizes an APA. In sum, as r increases (decreases), the noise in the contest outcome decreases (increases), and the contest becomes more deterministic (stochastic). The level of noise can therefore bring different incentives to invest effort and constitutes a mechanism to level the playing field. First, we focus on the designer's choice between two contest regimes: the lottery

[15]"Observations" are numbered according to the respective main mechanisms and sub-mechanisms, in that order. For example, the first observation made for Sub-mechanism 2 (Quotas) under main Mechanism 4 (Reward structure) is numbered as 4.2.1.

L $(r=1)$ and the APA $(r \to \infty)$. Then, we focus on the optimal choice of continuous noise level $r \in [0, \infty)$.

4.1.1 | Choice of contest regime and artificial exclusion of players

Consider n players competing for a prize; players are indexed according to their prize valuations such that $v_1 \geq v_2 \geq \cdots \geq v_n > 0$. Individual winning probability is generally represented by the Tullock CSF (Equation (2)), and the designer has the flexibility to choose between two contest regimes—the L $(r=1)$ and the APA $(r=\infty)$—in order to maximize aggregate effort (Fang, 2002). In addition, the designer can choose the optimal set of players according to their prize valuations.

Observation 1.1. When the contest designer can choose the competing set out of a finite set of players with given prize valuations, then

i. excluding some high valuation players can be optimal in an APA, but is never optimal in a lottery;
ii. total effort under the optimal lottery is higher than total effort under the optimal APA if the two highest valuations among the competing players in the APA are sufficiently close but not the same;
iii. total effort under the optimal lottery is lower than total effort under the optimal APA when players are perfectly homogeneous.

Support. The most extreme form of handicap is the exclusion principle coined by Baye et al. (1993), who show that excluding the player with the highest valuation may generate the highest total effort in an APA. The expected total effort in an APA is maximized when the set of active players—that is, players spending a positive amount of effort with a positive probability at some equilibrium—is given by $\{k^*, k^*+1, \ldots, n\}$, where k^* is the minimum k such that

$$\left(1+\frac{v_{k^*+1}}{v_{k^*}}\right)\frac{v_{k^*+1}}{2} \geq \left(1+\frac{v_{i+1}}{v_i}\right)\frac{v_{i+1}}{2} \qquad \forall i \in N. \tag{6}$$

The expected total effort in an APA with a total effort maximizing designer is given by

$$R^{\mathrm{APA}}(k^*, \ldots, n) = \left(1+\frac{v_{k^*+1}}{v_{k*}}\right)\frac{v_{k^*+1}}{2}. \tag{7}$$

The rank order of players' valuations has crucial importance in an APA. Depending on the rank order of their valuations, some players may never spend any positive effort. On the other hand, the total effort maximizing contest designer has an incentive to artificially exclude some players with a higher valuation than v_{k^*}, who would otherwise spend positive expected efforts using a mixed strategy (Baye et al., 1993). For $v_1 = v_2 = \ldots = v_m \geq v_{m+1} \geq \ldots \geq v_n$, players $m+1$ through n certainly spend zero effort in equilibrium, but the designer does not make a gain by excluding any player. For $v_1 > v_2 = \ldots = v_m \geq \ldots \geq v_n$, however, Player 1's expected effort in equilibrium is positive, but the contest designer gains from excluding Player 1 from the contest. See Baye et al. (1996) for a complete characterization under complete information.

Fang (2002) invalidates the exclusion principle in a lottery and claims the superiority of the lottery over the APA by showing that total effort maximization under the lottery does not call for any artificial exclusion and generates a higher equilibrium total effort for the designer, as well as a higher expected total player surplus. The total effort is given by

$$R^L(1, 2, \ldots, n) = \frac{n^* - 1}{\sum_{i=1}^{n^*} \frac{1}{v_i}}, \tag{8}$$

where $N^* = \{1, 2, \cdots, n^*\}$ is the set of players spending positive effort in the equilibrium; it is defined below.

$$N^* = \left\{ i : \frac{i-1}{v_i} < \sum_{j=1}^{i} \frac{1}{v_j}, \quad i = 1, 2, \cdots, n^* \right\} \quad \text{and } n^* = |N^*|. \tag{9}$$

Note that if $m \in N^*$, then it must be that $m - 1 \in N^*$ for all $m = 2, \cdots, n^*$. All players $i \leq n^*$ spend positive effort and all players $i > n^*$ spend zero effort at the unique pure-strategy equilibrium of the lottery. Among the players spending positive effort in equilibrium, those with higher valuation spend higher effort. Excluding any $i \leq n^*$ reduces total effort, and excluding any $i > n^*$ leaves total effort unaffected. Hence, exclusion is not optimal in the lottery.[16] In other words, $R^L(1, \cdots, n) \geq R^L(1, \cdots, m)$ for all $1 \leq m < n$. Hence, $R^L(1, \cdots, n) \geq R^L(1, 2)$. But $v_1 \geq v_2 \geq \ldots \geq v_n$ ensures that $\frac{1}{v_1} + \frac{1}{v_2} \leq \frac{1}{v_{k^*}} + \frac{1}{v_{k^*+1}}$ for all $k^* \in \{1, \ldots, n-1\}$, so that $R^L(2) = \left(\frac{1}{v_1} + \frac{1}{v_2}\right)^{-1} \geq \left(\frac{1}{v_{k^*}} + \frac{1}{v_{k^*+1}}\right)^{-1} = \frac{v_{k^*} v_{k^*+1}}{v_{k^*} + v_{k^*+1}}$. It is straightforward to show that $R^L(n) - R^{\text{APA}}(n) \geq R^L(2) - R^{\text{APA}}(n) > 0$ if $\frac{v_{k^*} v_{k^*+1}}{v_{k^*} + v_{k^*+1}} - \left(1 + \frac{v_{k^*+1}}{v_{k^*}}\right) \frac{v_{k^*+1}}{2} > 0$. This condition is true whenever $v_{k^*+1} < \left(\sqrt{2} - 1\right) v_{k^*}$. A total effort maximizing contest designer, therefore, prefers the L over the APA as long as the top two players in the optimal APA are only sufficiently close in terms of their reward valuations.

Note however that this conclusion is reversed for a perfectly homogeneous contest with a finite number of players; the equilibrium total effort indicates under-dissipation in a lottery ($v_i = v \ \forall i \in N$ implies $R^L(1, 2, \cdots, n) = (n-1)v/n$ from Equation (8)) and full dissipation in an APA ($v_i = v \ \forall i \in N$ implies $R^{\text{APA}}(1, 2, \cdots, n) = v$ from Equation (7)).

[16] Cohen and Sela (2005) show that the exclusion principle can be endogenously obtained for a lottery with winner reimbursement, where the strongest player stays out if he/she is not very strong compared to the other players. Matros and Armanios (2009) also consider a lottery with reimbursements and indicate that total effort is maximized (minimized) with winner (loser) reimbursement.

4.1.2 | Continuous choice of noise level in a general stochastic contest

Next, we assume that the designer has full flexibility in choosing $r \in [0, \infty)$ in the general Tullock CSF. As the level of noise in a contest decreases (or r increases), a player spending marginally more effort has a higher increase in his/her probability of winning, ceteris paribus, which encourages the stronger player to invest more (Nti, 2004). Hence, tweaking r is equivalent to tweaking the level of noise in the contest outcome. For example, in cricket, the match length can have different formats ranging from a couple of hours to 5 days, allowing the noise of the outcome to decrease with time. Likewise, the winner of a tennis match is determined either by a best-of-three or best-of-five set format, allowing the noise of the outcome to decrease with the number of sets.

Observation 1.2.1. Ceteris paribus in a two-player Tullock contest

i. total effort is maximized under a limited yet positive amount of noise (i.e., a finite positive value of r) in the effort impact function;
ii. the optimal level of noise is higher for greater levels of heterogeneity.

Support. In a two-player contest with $v_1 \geq v_2$, there is an $\bar{r} \in (1, 2]$ such that $(v_1/v_2)^{\bar{r}} = 1/(\bar{r}-1)$, and there is a unique pure strategy equilibrium if and only if $r \in (0, \bar{r}]$ (Nti, 1999, proposition 3). Further, for $r \in (0, \bar{r}]$, total effort increases with r when heterogeneity is low enough, that is, $v_1/v_2 \leq 3.57$ (Wang, 2010), and is a concave function of r when heterogeneity is higher. When $r \in [\bar{r}, 2]$, the stronger player always spends a unique effort and the weaker player randomizes between staying inactive and participating with a unique effort (Wang, 2010); this equilibrium is unique (Ewerhart, 2017b). When $r \geq 2$, there is an APA equilibrium in which both players randomize (Alcalde & Dahm, 2010; Wang, 2010).[17] Figure 1 exemplifies these results through a contest with two players that have high heterogeneity ($v_1/v_2 = 6$) or low heterogeneity ($v_1/v_2 = 2$).[18] For the case with high heterogeneity, total effort achieves its maximum value, approximately 0.146, when $r \approx 0.861 < \bar{r}$. For the case with low heterogeneity, total effort is maximized (with a value approximately 0.416) when $r = \bar{r} \approx 1.383$. This example provides us with two important intuitions. First, total effort is maximized at some $r \in (0, 2)$ in both cases, indicating that it can be optimal for the contest designer to inject some noise into the contest. Second, depending on the level of heterogeneity among the players, the designer should inject different levels of noise into the contest to extract the maximum possible effort.

[17] Ewerhart (2017a) shows that for a generic probabilistic contest, the APA equilibrium is robust when the probabilistic contest is decisive enough; that is, when a player's odds of winning largely increase with a marginal rise in effort. Moreover, any equilibrium of the probabilistic contest is payoff-equivalent and total effort-equivalent to the corresponding APA equilibrium when the latter is unique. Otherwise, there may be multiple payoff-nonequivalent equilibria.

[18] Wang (2010, p. 9) provides an example of high heterogeneity in costs $c_2 = 6c_1$, which can be easily transformed to heterogeneity in prize valuations. Figure 1 provides the same instance as in Wang (2010) for high heterogeneity, and an additional example for low heterogeneity with $c_2 = 2c_1$ or $v_1 = 2v_2$.

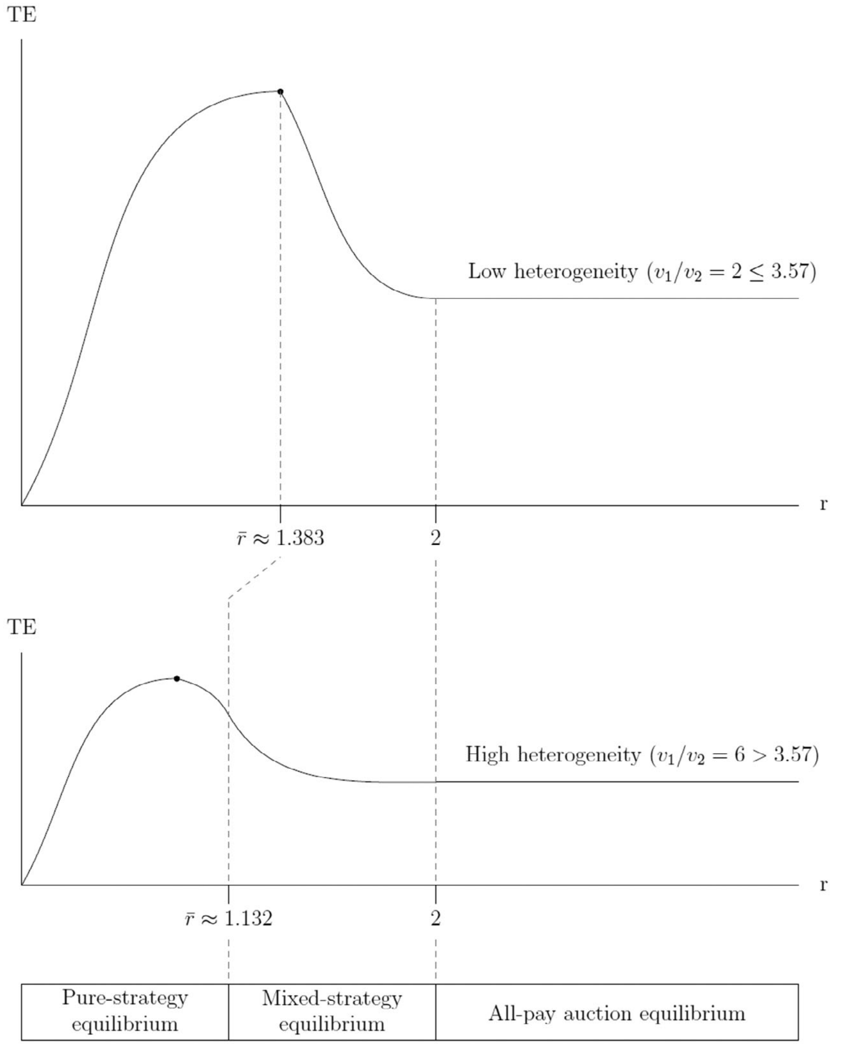

FIGURE 1 Relationship between total effort (TE) and the accuracy level (r) in a Tullock (1980) contest with two players and prize valuations satisfying either $v_1/v_2 = 6$ (high heterogeneity; Wang, 2010) or $v_1/v_2 = 2$ (low heterogeneity)

Observation 1.2.2. Ceteris paribus, in an n-player Tullock contest

i. participation falls as noise in the effort impact falls;
ii. the optimal noise depends on the shape of the cost function.

Support. In an n-player setting, Cornes and Hartley (2005) demonstrate that for an impact function of the form $x_i = \alpha_i e_i^r$ where α_i captures the natural heterogeneity among the players and the designer can only decide the universally applicable value of r, the number of active players is bounded above at $r/(r-1)$ when $r > 1$. Thus, the maximum number of active players falls as r rises, that is, as noise in the effort impact falls.

> Morgan et al. (2022) interpret the noise in performance ranking as the level of meritocracy in a contest. In other words, the lower the noise in effort outcomes, the more meritocratic the contest is. In an n-player Tullock contest, they show that the highest level of r for which there is an equilibrium in pure strategies (again, let us denote this as $\overline{r}$) uniquely maximizes total effort when the effort costs are convex. For linear costs, total effort is maximized at any r above $\overline{r}$. They also indicate that this optimal r strictly decreases in the number of players, n. The authors obtain comparable outcomes in an n-player tournament model, where they assume that the distribution of the noise in the effort impact, ε, is scaled down by a factor σ, where $\sigma \to 0$ implies perfect meritocracy. The optimal σ is unique (i.e., total output is maximized at $\sigma = \overline{\sigma}$) under convex costs, and there is a continuum of values of $\sigma \in (0, \overline{\sigma}]$, which maximizes output and produces Pareto efficient outcomes when effort costs are linear. Participation is also at the maximal level at this optimal σ and players start dropping out as σ falls further below. In this framework, perfect meritocracy turns out to be sub-optimal for both homogeneous or sufficiently heterogeneous contests, but can be optimal for a moderate level of heterogeneity.

Another interesting possibility is that otherwise similar players may differ in terms of r_i as considered by Cornes and Hartley (2005). The individual best response for $r_i \leq 1$ is strictly positive (Perez-Castrillo & Verdier, 1992), whereas multiple possibilities exist for $r_i > 1$: Player i has a strictly positive best response, two best responses $e_i^{\mathrm{BR}} = \{0, (r_i - 1/r_i)v\}$, or the best response is zero effort depending on whether the sum of the effort impacts from other players ($\sum_{j \in N \setminus i} e_j^{r_j}$) is less than, equal to, or greater than the threshold value $(r_i - 1)^{r_i - 1}(v/r_i)^{r_i}$, respectively (Cornes & Hartley, 2005; Perez-Castrillo & Verdier, 1992). The set of active players at the equilibrium may not be unique, but there is a unique equilibrium for any active set.

4.2 | Mechanism 2: Bias in the effort impact function

One of the most widely modeled tools for leveling the playing field is to introduce bias into the effort impact function of the players. This can be best understood with reference to the effort impact function $x_i = \alpha_i e_i + \theta_i$ used by Gradstein (1995) and Runkel (2006b), as described in Section 2. The contest designer can bias the contest in favor of one of the players (or a group of players) by assigning different parameter values to different players' impact functions. A multiplicative bias is modeled as $\alpha_i \neq \alpha_j$ and an additive bias is modeled as $\theta_i \neq \theta_j$. Recent findings show that the multiplicative and additive biases drive different incentives, which has an impact on the aggregate effort. In the following section, we explain these differences and their interaction with the CSF.

4.2.1 | Multiplicative bias

Under the sole application of multiplicative bias (i.e., normalizing the additive parameter to zero), the players' effort impact functions take the form $x_i = \alpha_i e_i$.[19] Suppose that the contest designer can affect players' effort impact functions by assigning a vector of weights

[19]Clark and Riis (1998b) axiomatize contests with multiplicative bias.

$\boldsymbol{\alpha} = (\alpha_1, \alpha_2, ..., \alpha_n) \in (0, \infty)^n$, where α_i is the weight assigned to Player i's effort. Accordingly, in modifying the CSFs for the lottery (Equation (2) with $r = 1$) and the APA (Equation (3)), we obtain the following.

$$p_i^L(\boldsymbol{\alpha}, \boldsymbol{e}) = \begin{cases} \dfrac{\alpha_i e_i}{\sum_{j \in N} \alpha_j e_j} & \text{if } \sum_{j \in N} \alpha_j e_j > 0 \\ \dfrac{1}{n} & \text{if } \sum_{j \in N} \alpha_j e_j = 0 \end{cases}, \tag{10}$$

$$p_i^{\text{APA}}(\boldsymbol{\alpha}, \boldsymbol{e}) = \begin{cases} 1 & \text{if } \alpha_i e_i > \max\left\{\boldsymbol{\alpha}_{-\boldsymbol{i}}^T \boldsymbol{e}_{-\boldsymbol{i}}\right\} \\ \dfrac{1}{k} & \text{if } \alpha_i e_i = \max\left\{\boldsymbol{\alpha}^T \boldsymbol{e}\right\} \text{ and } k = \left|j \in N : \alpha_j e_j = \max\left\{\boldsymbol{\alpha}^T \boldsymbol{e}\right\}\right| \\ 0 & \text{otherwise} \end{cases}. \tag{11}$$

In a two-player APA between one advantaged and one disadvantaged player (i.e., $v_1 > v_2 > 0$), Fu (2006) shows that extracting maximal effort from both players requires attaching a multiplicative bias of v_1/v_2 to the disadvantaged player's (here, Player 2) effort. This bias also maximizes the expected payoffs to both players and equalizes their chances of winning.[20]

With the optimal multiplicative bias, total effort under the APA dominates the total effort under the lottery. Franke et al. (2014) examine the optimal multiplicative bias to maximize total effort. They demonstrate that the conditional superiority of the lottery to the APA (Fang, 2002), as outlined in Section 4.1, is unconditionally reversed with the introduction of optimal multiplicative bias into the effort impact function. The choice problem faced by the contest designer can be formulated as a three-stage game. In the first stage, the designer chooses between an APA and a lottery. In the second stage, he/she chooses the agent-specific biases $\boldsymbol{\alpha} = \{\alpha_1, \alpha_2, \cdots, \alpha_n\} \in (0, \infty)^n$, and in the final stage, the players choose their efforts. Standard backward induction then gives the Subgame Perfect Equilibrium.

Under this modified contest, the payoff function (Equation (5)) can be written as $\pi_i(\boldsymbol{\alpha}, \boldsymbol{e}) = p_i(\boldsymbol{\alpha}, \boldsymbol{e})v_i - e_i$ for all $i \in N$. Multiplying both sides by α_i gives the expression $\alpha_i \pi_i(\boldsymbol{\alpha}, \boldsymbol{e}) = p_i(\boldsymbol{\alpha}, \boldsymbol{e})\alpha_i v_i - \alpha_i e_i$. This is equivalent to a standard contest with transformed efforts $\alpha_i e_i$ and transformed valuations $\alpha_i v_i$ for all $i \in N$. For heterogeneous biases, an ordered arrangement of these transformed valuations may be different from the order of the original valuations. Drawing a contrast with Section 4.1, in what follows, we consider the APA and the lottery under these transformed valuations.

> *Observation* 2.1. When the contest designer can choose the optimal bias vector for a finite set of players with given valuations under any contest regime, then the total effort in the optimally biased APA is higher than the total effort in the optimally biased lottery. The optimal APA equalizes the stakes of the active players, while some heterogeneity is preserved in the optimal lottery.

[20]Applying this simple model in the context of college admissions, Fu (2006) indicates that this optimal bias indeed maximizes the expected quality of the admitted student. However, the advantaged player becomes more aggressive, resulting in a higher performance gap between the advantaged and the disadvantaged player in the equilibrium.

Support. To analyze the APA under these transformed valuations, let us first consider an arbitrary bias where weights are assigned so as to keep the order of the valuations the same after the transformation, that is, given $v_1 \geq v_2 \geq ... \geq v_n$, α_i for all i are chosen such that $\alpha_1 v_1 \geq \alpha_2 v_2 \geq ... \geq \alpha_n v_n$. For example, a vector $\boldsymbol{\alpha}$ with $\alpha_1 = \frac{1}{v_1}, \alpha_2 = \frac{1}{v_2}$ and $\alpha_i = \frac{1}{2v_3}\ \forall\ i > 2$ satisfies this condition because the corresponding transformed valuations are then $\alpha_1 v_1 = \alpha_2 v_2 = 1$ and $\alpha_i v_i \leq \frac{1}{2} < 1$ for all $i > 2$ and $\alpha_j v_j \leq \alpha_i v_i$ for any $j < i$. Note that the unbiased APA also satisfies this condition as the bias vector (1, 1, ..., 1) essentially preserves the original order of the valuations. According to the standard properties of the APA (theorem 1 in Baye et al., 1996), the transformed APA has a unique Nash equilibrium, where expected efforts are $E(\alpha_1 e_1)^* = E(\alpha_2 e_2)^* = \frac{1}{2}$ and $E(\alpha_i e_i)^* = 0$ for all $i > 2$. The total effort is $\frac{1}{\alpha_1} E(\alpha_1 e_1)^* + \frac{1}{\alpha_2} E(\alpha_2 e_2)^* = \frac{1}{2}(v_1 + v_2)$. Hence, total effort under optimal bias must be at least as much as this. On the other hand, by arranging the transformed valuations in decreasing order and applying the solution concept from Baye et al. (1996), one can show that $\frac{1}{2}(v_1 + v_2)$ is also the upper bound of maximum effort (see Franke et al., 2014, proposition 3.3). Hence, the equilibrium total effort under the optimal bias vector $\boldsymbol{\alpha}^*$ is

$$R^{\mathrm{APA}}(\alpha^*) = \frac{1}{2}(v_1 + v_2), \tag{12}$$

which is greater than v_2, the maximum total effort obtainable under the unbiased APA for $v_1 \geq v_2 \geq \cdots \geq v_n$.[21]

Next, to consider a lottery under these transformed valuations, let $\widetilde{N} = \left(\widetilde{1}, \widetilde{2}, \cdots, \widetilde{n}\right)$ denote the permutation of the player indices on N such that $\alpha_{\widetilde{1}} v_{\widetilde{1}} \geq \alpha_{\widetilde{2}} v_{\widetilde{2}} \geq \cdots \geq \alpha_{\widetilde{n}} v_{\widetilde{n}}$. Using Equation (9), the set of players exerting positive effort in equilibrium can be denoted as

$$\widetilde{N}^* = \left\{ i : \frac{i-1}{\alpha_i v_i} < \sum_{j=1}^{i} \frac{1}{\alpha_j v_j}, \quad i = \widetilde{1}, \widetilde{2}, \cdots, \widetilde{n}^* \right\} \quad \text{with}\ \widetilde{n}^* = |\widetilde{N}^*|. \tag{13}$$

Franke et al. (2013, theorem 4.2(d)) reveal that an optimal bias in L yields a total effort of

$$R^L(\alpha^*) = \frac{1}{4}\left[\sum_{i \in \widetilde{N}^*} v_i - \frac{\left(\widetilde{n}^* - 2\right)^2}{\sum_{i \in \widetilde{N}^*} \frac{1}{v_i}} \right]. \tag{14}$$

[21]This may not be true under incomplete information. For example, in a two-player APA with private valuation where one player enjoys multiplicative bias and the other player is thereby consequentially handicapped, Walzl et al. (2002) indicate that the handicapped player does not win with positive probability if he/she has the lower valuation. Hence, the only possibility for inefficient allocation is when the low valuation player is favored and also wins in the equilibrium. They obtain the expected welfare loss due to such inefficient allocation and demonstrate that such loss increases along with the magnitude of the bias.

The optimal bias cannot be determined uniquely. Nonetheless, Franke et al. (2013) imply that the natural ordering of players is preserved under optimal bias, and the set of active players in the optimally biased lottery is at least as large as the set of active players in the unbiased lottery. Using Equations (8) and (14) and the basic mathematical property that the harmonic mean of a set of positive values is always less than the arithmetic mean of the same set of values, one can illustrate that $R^L(\alpha^*)$ is strictly higher than R^L whenever $\widetilde{n}^* = n^*$. This difference shrinks as more players become active in the optimally biased lottery than in the unbiased lottery because the optimal bias increases participation from the weaker players at a relative disadvantage to the stronger players. However, this relative disadvantage should only be enough to induce both weaker and stronger players to exert higher effort. Otherwise, total effort in the biased lottery may be lower than under the unbiased lottery. For example, in a general Tullock contest (of which the lottery is a special case) with heterogeneous costs ($c_i = \gamma_i e_i$), Franke (2012a) indicates that both the total and individual efforts are higher under optimal multiplicative bias than under equal treatment in a two-player contest, but this outcome might not always hold in an n-player contest with $n > 2$. When all players are treated equally, there is a positive probability that only a subset of players $M \in N$ is active, thus incentivizing the stronger players to exert higher effort. With the optimal bias, on the other hand, all players are always active. This participation effect of the AA, in addition to the lower effort impact of the stronger players, can suggest that AA drives a lower total effort compared to equal treatment. The author concludes that, in the n-player game, AA is likely to generate a higher total effort compared to equal treatment when the effort costs are not too heterogeneous, to begin with.

Now let us consider a sufficiently small increase in the valuation of any Player $i \in N$. Given Equation (13), if i is strictly inactive (i.e., $i \notin \widetilde{N}^*$) prior to this marginal change in valuation, then this small increase does not make him/her active. On the other hand, if i is indifferent between being active and not, then a marginal increase in valuation induces him/her to be active with a rise in total effort (Franke et al., 2014, lemma 4.2). Similarly, if i is strictly active prior to this marginal increase, then a marginal increase in his/her valuation further augments total effort. Hence, total effort in a lottery with player valuations $(v_1, v_2, v_2, v_4, ..., v_n)$ is greater than the total effort in a lottery with $(v_1, v_2, v_3, ..., v_n)$. By induction, total effort with $(v_1, v_2, v_2, ..., v_2)$ is greater than the total effort with $(v_1, v_2, v_3, ..., v_n)$. Using the expressions for total effort under the optimally biased APA (Equation (12)) and the optimally biased lottery (Equation (14)),

$$R^{\mathrm{APA}}(\alpha^*, (v_1,\ v_2,\ ...,\ v_2)) - R^L(\alpha^*, (v_1,\ v_2,\ ...,\ v_2)) = \frac{v_1+v_2}{2} - \frac{1}{4}\left(v_1 + (n-1)v_2 - \frac{(n-2)^2}{\frac{1}{v_1}+\frac{n-1}{v_2}}\right)$$
$$= (n-1)v_1^2 + 2v_1v_2 - (n-3)v_2^2 = (n-1)\left(v_1^2 - v_2^2\right) + 2v_2(v_1+v_2) > 0.$$

Consequently, $R^{\mathrm{APA}}(\alpha^*) > R^L(\alpha^*)$ must be true for $v_1 \geq v_2 \geq ... \geq v_n$.

It was noted earlier that the APA is optimal over the lottery when players are homogeneous, and the lottery is preferable over the APA when players are only sufficiently heterogeneous. The sub-optimality of APA under moderate heterogeneity comes from the potential exclusion of high-valuation players. In the biased APA, however, total effort is maximized without excluding the high-valuation player(s). On the other hand, the optimally biased lottery also encourages greater participation compared to the unbiased lottery. Referring back to the above analysis with the transformed valuations, it is apparent that the optimal bias in APA equalizes the stakes of the two highest-valuation players, while the optimally biased lottery does not completely eliminate the heterogeneity. The optimal bias in APA thus ensures fierce competition between the two highest valuation players, and this competition effect outweighs the participation effect induced under the optimally biased lottery.

However, Epstein et al. (2013) invalidate this unconditional superiority of the biased APA over the biased lottery in a two-player contest where the contest designer can choose both the effort weights ($\boldsymbol{\alpha}$) and the level of noise (r) in the contest. In such a framework, the expected total effort under the optimal lottery equals the expected total effort from the optimal APA, that is, $R^L(r^*, \alpha^*) = R^{\mathrm{APA}}(\alpha^*)$.

The analytical tractability of multiplicative bias has driven many authors to look into various issues relating to the application of the bias, one such issue being the optimal target of the bias. Is it always beneficial to level the playing field in a heterogeneous contest? The answer depends on the sources of heterogeneity among the players and sometimes on the designer's objective as well.

- *Multiple sources of heterogeneity*: Fu and Wu (2020) consider that players can be heterogeneous not only in valuations, but also in the level of noise in their individual effort impact r_i (this latter possibility has also been examined by Cornes and Hartley (2005), as discussed in Section 4.1.2). Assuming a high amount of noise in the impact functions (i.e., $r_i \leq 1$ for all $i \in N$), they identify the equilibrium winning probabilities that maximize total effort and the optimal biases that induce such probabilities.[22] It turns out that, for settings with more than two players, the optimal bias does not have to be monotone with the players' valuations. Given the number of players n, the distribution of their valuations, and noise levels, the most favored players will be the ones who respond more sensitively to extra favoritism. Thus, the optimal biases can favor stronger players, weaker players, or even players in intermediate positions.
- *Designer's objective*: Heterogeneity among players is often modeled with heterogeneity in reward valuation, and the convention is to model the stronger player as the high-value player and the weaker one as the low-value player. However, Kräkel (2012) argues that in a given contest, the disadvantaged (advantaged) player(s) may have higher (lower) valuation due to their lower (higher) outside options, which increases (decreases) their effort incentives and the resulting winning probability. Epstein et al. (2011) point out that whether the higher value represents the stronger player depends on the contest scenario; for example, a higher valuation for a monetary prize may indicate relative poverty, whereas a higher valuation for an environmental or trade policy may be typical of the wealthier class. They further show that under both an APA and a Tullock CSF, greater concern for players' welfare will bias the contest in favor of the high-valuation player and generate more concern for total effort calls for biasing the contest in favor of the low-valuation player. As such, if high valuation embodies low-income sectors of society competing for a resource, then the socially optimal

[22]Moreover, Fu and Wu (2020) explore maximizing the winner's expected effort as an alternative objective function for the designer.

policy is to favor the poor. Likewise, for high valuation representing the wealthier part of society lobbying for a certain policy, favoring the wealthier player is socially optimal for a welfare-maximizing government.

- *Uncertainty regarding player identity in a dynamic contest*: The designer's decision regarding whom to favor in a contest becomes trickier in the presence of uncertainty regarding the players' advantages. This can often be the case in a dynamic contest where the designer, at a later point in the contest, knows that the players were ex-ante heterogeneous, but is able to observe only the outcome of the preceding stage. As discussed previously in Section 3.2, relative advantages in later stages of a dynamic contest can arise due to outcomes attained in earlier stages. Consider a two-period, two-player contest where the designer can choose to favor one of the players in the last period. Assuming the two players can be heterogeneous in terms of both valuation and ability, the designer can affect the ability ratio α_2/α_1 by multiplying it with an AA bias λ such that $\lambda = \alpha_1 v_1/\alpha_2 v_2$. If players have identical valuations, then the optimal AA multiplier under the APA is equal to α_1/α_2, and in the lottery, it is less than α_1/α_2. However, the implementation of this mechanism is not possible if the designer cannot distinguish the weaker player from the stronger one. The crux of the problem then becomes the prevalence of incomplete information, which complicates the determination of the optimal target of AA. Suppose the designer still knows the common valuation v and ability ratio α_1/α_2 but does not know which player is weaker. $\alpha_2 < \alpha_1$ implies that a correctly targeted policy will alter the ability ratio to $\lambda\alpha_2/\alpha_1$, while an incorrectly targeted action will alter it to $\alpha_2/\alpha_1\lambda$. In a static contest, the optimal λ will approach α_2/α_1 as the probability of incorrect targeting becomes larger, shifting the optimal bias away from the weaker to the stronger player. In a dynamic contest, the first-period outcome serves as a signal and the winner in the first-period contest is identified as the stronger player. Therefore, if Player 1 wins the first-period contest, he/she will be correctly identified as the stronger player, but if Player 2 wins the first-period contest, then he/she will be incorrectly identified as the stronger player. The direction of the AA will be different under the two circumstances. The players' implicit values of the first-period contest are determined by taking both possibilities into account. The equilibrium total effort is then a function of the ability ratio and the designer's bias. In a lottery contest where the two players have identical valuations but can be heterogeneous in terms of abilities, Ridlon and Shin (2013) show that under large ability differences, handicapping the first-period winner maximizes total effort, while handicapping the first-period loser is optimal when the abilities are similar. This is because favoring the first-period loser reduces effort incentives in the first period (ratcheting), while favoring the first-period winner lowers incentives in the second period (moral hazard). The authors argue that, in a lottery, the optimal policy depends on the value of α_2/α_1 because it affects the implicit valuations of the first contest. A policy in favor of the loser less than fully compensates for the ability difference in a lottery. Hence, the disadvantage of winning the first contest causes the implicit valuations to fall below the true values for both players, but more so for the stronger one. This causes a stronger incentive for the weaker player only when abilities are sufficiently different. Under a reverse policy, however, the weaker player's success probability is lower than the stronger player's, even when the former wins the first contest.[23]

[23]This finding is likely true in an APA as well. For example, Harbaugh and Ridlon (2011) show that the expected total effort under a policy of favoring the loser is strictly higher than when favoring the winner in an APA.

4.2.2 | Additive bias

Next, let us consider contests where the players' impact functions have the form $x_i = e_i + \theta_i$, with θ_i being an additive bias. Such an impact function is often used to model head start advantages.

Observation 2.2. An optimally chosen additive bias increases total effort in both an APA and a tournament, but is ineffective in a lottery.

Support. Franke et al. (2018) and Liu and Lu (2017) analyze a lottery and an APA with additive bias and, similarly to Section 4.2.1, they find that total effort under an optimally chosen bias vector is larger in the APA than in the lottery. In the lottery, the additive bias becomes a perfect substitute for individual effort; thus, it is optimal for the designer to avoid using it. However, under APA, the optimal additive bias can increase total effort. In this case, total effort increases with the difference in valuations between the strongest player and the rest of the players.

Seel and Wasser (2014) consider additive biases or head starts in an APA with uniformly distributed, independent and identically distributed (IID) private values. Here, the contest designer maximizes a weighted sum of the expected average and the expected highest effort. They establish the uniqueness of an optimal head start, which is positive only when the weight on the highest effort is large enough. Siegel (2014) also considers additive biases in both single-prize and multi-prize APAs. He assumes identical valuation but heterogeneous biases across players. If a unique equilibrium exists in a contest with m prizes and the players are ordered such that $\theta_1 \geq \theta_2 \geq \cdots \geq \theta_n$, then all players $i \in \{i : \theta_i \geq \theta_{m+1} + v\} \cup \{m+2, \cdots, n\}$ choose an effort equal to their respective head starts in that equilibrium. Kitahara and Ogawa (2010) construct the Bayesian-Nash equilibrium for an APA with individual handicaps, and claim that the total effort falls in the maximum handicap when players' valuations follow a uniform distribution.

Additive biases are also used in tournaments. Schotter and Weigelt (1992) were the first to study players' behavior in a tournament setting with an additive bias in favor of the weaker player. In their model, players belong to either a cost-advantaged group or a cost-disadvantaged group. Their experimental findings indicate that total tournament effort is increased by the additive bias only when the cost difference between groups is severe; without the additive bias, disadvantaged players drop out of the competition. Their experimental results, however, are contradictory to their theoretical outcomes. Fain (2009) points out a shortcoming in the theoretical model in Schotter and Weigelt (1992) and presents a more complete argument of the effects of leveling the playing field in a tournament. In Fain (2009)'s two-player tournament model, the players are assumed to have the same valuation for the contest reward but different costs of effort. Considering a two-player tournament where the winner receives a common value v and the loser gets nothing, and assuming Player 2 to be the cost-disadvantaged player, the payoff functions of the two players are given by $\pi_1 = p_1 v - c e_1^2$ and $\pi_2 = p_2 v - \beta c e_2^2$, with $\beta > 1$ and $c < 1$. Under an additive bias θ in favor of the weaker (cost-disadvantaged) player, Player 1 receives v if $x_1 > x_2 + \theta$ and zero if otherwise. Following Equation (4), Player 1's winning

> probability can be expressed as $F(e_1 - e_2 - \theta)$, where $F(\cdot)$ is the CDF of $(\epsilon_2 - \epsilon_1)$. The payoff functions of the two players can therefore be written as $\pi_1 = F(e_1 - e_2 - \theta)v - ce_1^2$ and $\pi_2 = (1 - F(e_1 - e_2 - \theta))v - \beta ce_2^2$. The first order condition for payoff maximization can be written as $f(e_1 - e_2 - \theta)v = 2ce_1 = 2\beta ce_2$. Since $e_1 = \beta e_2$, the maximum value of e_2 ensures maximum total effort. If $F(\cdot)$ follows a normal distribution with a mean of zero and positive variance, then $f'(\cdot)$ is zero only when the functional argument takes a zero value. In the present context, this means $(\beta - 1)e_2 = \theta$ or $e_2 = \theta/(\beta - 1)$. Yet at $(\beta - 1)e_2 = \theta$, the probability of either player winning is $f(0) = 0.5$ implying complete leveling of the playing field. If, on the other hand, $F(\cdot)$ follows a uniform distribution, then the optimal efforts depend on the relative value of the effort difference $(e_1 - e_2)$ and θ. Total effort, as well as individual efforts, are maximized at the mode of the distribution, where θ is positive and the success probabilities of the two players are again one-half. Fain (2009) also shows that the total effort at this level is greater than the total effort with $\theta = 0$, as is the case in an unbiased tournament. Lee (2013) finds a positive impact of AA on total effort in a tournament with several prizes. He concludes that an additive bias favoring the disadvantaged group improves overall effort as long as the players' performances are informative enough of their efforts. In this case, a rise in the ex-ante disadvantageous group's performance exceeds the fall in the ex-ante advantaged group's performance, and equalizes the winning opportunities of both groups.

In this respect, the empirical observations by Estevan et al. (2019) about the effects of an AA policy in the form of an additive bias implemented by a Brazilian public university are worth a mention. The particular benefit is in the form of 30 bonus points added to the college admissions scores of the public high school students, with a smaller additional bonus of 10 points for those who come from disadvantaged backgrounds. Building on the theoretical model of Stein (2002), they predict an increase (a decrease) in the performance and success probability of the receivers (non-receivers) of the bonus. The results indicate a significant increase in the admissions probability and college participation rate of public school students irrespective of their socio-economic background, but there were no significant improvements in their test performance. In fact, the test score of the private school applicants exhibited a marginal improvement.

Chan (1996) considers additive handicaps in the context of a promotional tournament for positions within a firm. The author argues that the optimal handicap policy depends on the threat from external candidates. If external candidates are much more capable relative to the existing employees, then preferential treatment favoring internal candidates will incentivize them to work harder. On the other hand, if the external threat is sufficiently low, then handicapping internal candidates will boost the firm's current performance. These conclusions are supported empirically by Chan (2006), who asserts that the probability of external recruitment at a U.S. financial company is significantly higher at lower levels of the job hierarchy due to a higher threat from external candidates. He further demonstrates that a handicap on external candidates results in external candidates of higher ability being taken in, which is evident from the external recruits outperforming the internally promoted ones during subsequent promotions. In analyzing personnel data from a German company, Pfeifer (2011) reveals that outsiders' promotion advantage over that of insiders is mostly explained by outsiders possessing higher educational qualifications and experiences.

Tsoulouhas et al. (2007) explore a similar problem in a two-period model where the firm faces a trade-off between maximizing current output by incentivizing insiders, and obtaining a greater future output by choosing the most efficient manager. This trade-off leads to an optimal strategy of handicapping insiders when outsiders are significantly more efficient. The conclusions reached by Chan (1996) and Tsoulouhas et al. (2007) are thus contradictory due to the dynamic structure of the latter model compared to the static nature of the former.

4.2.3 | Additive and multiplicative biases

In a lab-in-the-field experiment among schoolchildren, Calsamiglia et al. (2013) find that both additive and multiplicative biases toward the disadvantaged players (in this case, a disadvantage implies lower task competence) increase average performance and also increase the disadvantaged players' representation among the winners. It is nonetheless important to note that the multiplicative bias affects the marginal return on effort, while the additive bias does not, which may lead to different strategies and outcomes. A few example scenarios examined in the literature where the additive and multiplicative biases have been compared are as follows:

- *Simultaneous contest*: In simultaneous contests, Li and Yu (2012) explore an APA with two players where the contest designer decides the optimal bias toward the weaker player so as to maximize the contest revenue by fully eliminating the heterogeneity between the two players. They find that aggregate effort is larger under the optimal additive bias compared to the optimal multiplicative bias. Kirkegaard (2012) also investigate a two-player APA with both additive and multiplicative biases. He shows that an additive bias favoring the weaker player always increases aggregate effort, while a multiplicative bias that handicaps the stronger player may have mixed effects. He advises combining the two biases if there is a high level of heterogeneity between the two players' abilities. These two results contrast with the recommendations of Pastine and Pastine (2012b), who consider an additive AA bias in a similar contest setup, that is, a contest between one advantaged player and one disadvantaged player, as used by Fu (2006) to study multiplicative bias. Pastine and Pastine (2012b) find a larger performance gap and, unlike Fu (2006), the success probability of the disadvantaged player does not improve. The AA bias required to ensure diversity is higher compared to Fu (2006), indicating an even greater gap in performance. They conclude that a multiplicative advantage is preferable to an additive advantage from an incentive angle. See Dahm and Porteiro (2008) for an assessment of multiplicative and additive biases in a rent-seeking context with a lottery CSF.
- *Sequential contest*: Segev and Sela (2014) analyze the effect of an additive versus multiplicative bias in a sequential APA with two players. A multiplicative bias is likely to incentivize the first-mover to invest more effort, but may cause the second-mover to withdraw under certain circumstances. An additive bias on the other hand induces the second-mover to invest effort equal to the amount of the bias, while the first-mover invests zero effort in most circumstances. For maximizing the total expected effort, they invoke a combination of additive and multiplicative biases.
- *Appropriation contest*: Another interesting two-period setting is explored by Konrad (2002), where the first period contains investment by the Period 1 incumbent, and an appropriation contest over the fruits of this investment takes place in Period 2. The value of the prize in the second-period contest is determined by the amount invested by the Period 1 incumbent. In

modeling the incumbency advantage as a possible combination of an additive bias (the head start advantage) and a multiplicative bias (productivity advantage) (i.e., the incumbent wins the contest whenever his/her effort falls short of the opponent's effort by no more than the bias size), the author indicates that these biases set a critical threshold for the investment amount for obtaining positive appropriation efforts in Period 2.

- *CES impact function*: Esteve-González (2016) analyzes contests through an impact function that is a constant-elasticity-of-substitution function. In that case, the incumbent's multiplicative (additive) bias is interpreted as a perfect complement (substitute) of effort to solve a moral hazard problem. It turns out that aggregate effort is maximized when the bias and contest effort are not too complementary; in fact, there should be more substitutes when effort cost decreases.

While these examples can guide a designer in choosing between either type of bias, the obvious question that follows is whether it is optimal to use both types of biases (as suggested by Kirkegaard, 2012; Segev & Sela, 2014) when the designer has the flexibility to do so. The following observation presents the findings from the literature on optimal bias when the effort impact function can have both types of biases at the same time, that is, $x_i = \alpha_i e_i + \theta_i$.

Observation 2.3. A combination of additive and multiplicative biases increases total effort in an APA. However, the optimal level of additive bias in a lottery remains zero, even when the contest designer can combine the two types of biases.

Support. Nti (2004) and Runkel (2006b) demonstrate that the total effort in the 2-player lottery is maximized when the effort of the low-valuation player is boosted up with a multiplicative bias equal to the ratio of the high value to the low value. Both of these studies consider effort impact functions with simultaneous application of additive and multiplicative biases. When all players must be active, the optimally biased contest has no additive bias, and the optimal multiplicative bias equalizes the players' valuations such that $\alpha_1 v_1 = \alpha_2 v_2$. Nti (2004) further shows that when the designer enjoys full autonomy in the contest architecture, the optimal bias excludes the weaker player ($\alpha_2 = \theta_2 = 0$ following the notation in Section 2); for the stronger player, there is a combination of additive and multiplicative biases such that $\theta_1 = -\alpha_1 v_1$. In this equilibrium, the stronger player bids v_1, and the weaker player remains inactive. Franke et al. (2018) extend this result to more than two players and compare the expected aggregate effort between a lottery and an APA. It turns out that multiplicative biases are more effective in lotteries because more participation is induced.[24] However, additive biases are never optimal in a lottery, but are highly effective for maximizing effort in the APA. The authors generalize the total effort dominance outcome of Franke et al. (2014) and find that total effort is maximum if the designer combines multiplicative and additive biases under the APA. Aggregate effort in the lottery and the APA under the optimal additive and multiplicative biases can be unambiguously ranked as below.

[24]In the Tullock (1980) setting, Ewerhart (2017b) reveals that in contests with two heterogeneous players, total effort with the optimal multiplicative bias strictly increases with r until $r = 2$ and is constant for $r \geq 2$.

$$\text{If } v_1 = v_2, \text{then} \sum x_{(\alpha=\alpha^*,\ \theta=\theta^*,\ \text{APA})} = \sum x_{(\alpha=1,\ \theta=\theta^*,\ \text{APA})} = \sum x_{(\alpha=\alpha^*,\ \theta=0,\ \text{APA})}$$
$$> \sum x_{(\alpha=\alpha^*,\ \theta=0,\ L)} = \sum x_{\alpha=\alpha^*, \theta=\theta^*, L)} \geq \sum x_{(\alpha=1,\ \theta=\theta^*,\ L)}$$
$$\text{If } v_1 > v_2, \text{then} \sum x_{(\alpha=\alpha^*,\ \theta=\theta^*,\ \text{APA})} > \sum x_{(\alpha=1,\ \theta=\theta^*,\ \text{APA})} > \sum x_{(\alpha=\alpha^*,\ \theta=0,\ \text{APA})}$$
$$> \sum x_{(\alpha=\alpha^*,\ \theta=0,\ L)} = \sum x_{(\alpha=\alpha^*,\ \theta=\theta^*,\ L)} > \sum x_{(\alpha=1,\ \theta=\theta^*,\ L)}.$$

4.3 | Mechanism 3: Reward valuations and cost of effort

We have already seen that reward valuation is a predominant source of heterogeneity in a contest and can be crucial in determining the direction of optimal bias. Nevertheless, thus far, we have not considered tweaking the reward valuations of the players for leveling the playing field. The following observation builds on studies that consider manipulating the reward values by taxing or subsidizing the final rewards depending on the winner's identity.

Observation 3.1. An optimally taxed APA generates at least as much total effort as an optimally taxed Tullock contest. An optimally taxed APA completely eliminates the heterogeneity in reward valuations, whereas an optimally taxed Tullock contest still preserves some heterogeneity.

Support. Taxation leaves the CSF intact as in an unbiased contest; instead, it changes the reward values through post-contest taxation. In a two-player contest through optimal taxation of the reward, Mealem and Nitzan (2014) find support for Epstein et al. (2013)'s conclusion about the total effort equivalence between an optimally biased Tullock contest and an optimally biased APA (see Section 4.2.1). The realized reward value to Player i upon Player i's success is $v_i + \tau_i$. Player i therefore maximizes $\pi_i = p_i(e_i, e_j)(v_i + \tau_i) - e_i$, where $p_i(e_i, e_j)$ can be any contest technology. Using Equation (12) with valuations $(v_1 + \tau_1, v_2 + \tau_2)$, the expected total effort in APA is $(v_2 + \tau_2)(v_1 + \tau_1 + v_2 + \tau_2)/2(v_1 + \tau_1)$. For the general Tullock CSF, the expected total effort in the pure strategy Nash equilibrium is $r(v_1+\tau_1)^r(v_2+\tau_2)^r(v_1+\tau_1+v_2+\tau_2)/\left(v_1^r+v_2^r\right)^2$ for any $r \in (0, 2)$. Alcalde and Dahm (2010) suggest that there is an equilibrium in mixed strategies for Tullock contests with $r > 2$, which is comparable to the APA equilibrium. Under either regime, the contest designer chooses (τ_1, τ_2) to maximize the expected total effort subject to the balanced budget constraint $p_1\tau_1 + p_2\tau_2 = 0$. Mealem and Nitzan (2014) find that the optimal taxation under APA is $\left(\tau_1^*, \tau_2^*\right) = (-0.5(v_1 - v_2), 0.5(v_1 - v_2))$, which equalizes the two players' valuations from winning. That said, the optimal taxation under the Tullock technology with $r \in (0, 2)$ is such that $v_1 + \tau_1^* \geq v_2 + \tau_2^*$. Further, with the aid of Alcalde and Dahm (2010)'s neutrality result for $r > 2$, they show that the expected total effort under the optimally taxed APA is at least as large as the expected total effort under Tullock. Moreover, in support of Franke et al. (2014), they demonstrate that the total effort maximizing taxation scheme under APA aims to equalize the two players' final stakes, whereas, in a Tullock contest, the optimal scheme (reduces but) still preserves inequality between the final stakes.

Very few studies examine an endogenous reward scheme where the value of the reward received by a player is a function of the player's effort. Chowdhury (2017) shows that high degree of heterogeneity with effort dependent prize may result in pure strategy equilibria. Jönsson and Schmutzler (2013) argue that the ratio of expected highest effort to expected total effort is larger in an APA with endogenous or effort-dependent rewards than in an APA with fixed reward amounts. Endogenous rewards are therefore suitable for designers interested in obtaining the highest expected effort while also limiting effort wastage. While individual prizes in this study depend solely on the individual player's effort, making the prize value a function of players' identities can also be useful. Gürtler and Kräkel (2010) explore a two-player rank-order tournament and indicate that individual prizes allow the designer to fully extract the rent from the high-ability player by imposing a handicap. They also reveal that individual or identity-dependent prizes do not do worse than a uniform prize, even when a negative handicap is not possible.

Modifying the cost structure to create handicaps and head starts is another common practice for leveling the playing field. A decrease (increase) in the weaker (stronger) player's marginal cost can be interpreted as a head start (handicap). In many sports (e.g., car racing, chess, golf), handicapping is used to standardize the outcomes of heterogeneous players by mapping their scores according to their individual abilities. In particular, these rules aim to equalize the winning probabilities of players when they incur the same effort costs, whether the effort spent by them is equal or not. Handicap rules have been analyzed in the literature in the context of golf tournaments Franke (2012b) and horse racing (Brown & Chowdhury, 2017).

Observation 3.2. The impact of heterogeneity, in terms of effort cost, is analytically equivalent to the impact of heterogeneity in terms of prize valuation and effort impact, and can hence be corrected by similar policy measures.

Support. Heterogeneity, through cost functions, can be easily transformed into heterogeneity through prize valuations or impact functions under risk neutrality. Runkel (2006a) explains the analytical equivalence between a heterogeneous cost framework and a heterogeneous valuation framework in a two-player contest where $\mathrm{EU}_i = p_i(e_i, e_j)v - e_i(c_i + \theta_i)$, and θ_i is the designer's tool for modifying a player's cost function. By multiplying the expected utility by $1/(c_i + \theta_i)$, one can obtain the transformed expected utility $p_i(e_i, e_j)v_i - e_i$ where $v_i = v/(c_i + \theta_i)$. Analytical equivalence between effort cost and impact function has been investigated by Kirkegaard (2012) for linear effort costs, and by Alcalde and Dahm (2020) for general cost functions. For policymakers, however, introducing a change into the cost structure is often easier to implement than a change in the players' reward valuations or their effort impact functions.

4.4 | Mechanism 4: Reward structure

A popular policy tool affecting competitive balance is the reward structure, also referred to as the contest architecture. A designer with a given reward budget can decide how many prizes to award in a contest and how to allocate the budget among the different prizes when there is more than one prize. We examine four different policy mechanisms: manipulating the number of prizes; reserving some prizes for disadvantaged players (i.e., quotas); varying the reward sharing rule; and allocation of the reward budget in dynamic contests. All mechanisms modify the level of competitiveness in a contest.

4.4.1 | Number of prizes

Moldovanu and Sela (2001) and Moldovanu and Sela (2006) show that this mechanism depends on the effort cost of the players; in particular, the optimality of single or multiple prizes depends on the shape of the cost function.[25] When the CSF is an APA and each player exerts effort only once, it can be optimal for the contest designer to provide multiple prizes if players are risk-neutral and their effort costs are convex or if players are risk-averse and their effort costs are linear. When the CSF resembles a Tullock contest, the probability that an individual player can secure a prize increases, ceteris paribus, when more prizes are available; this encourages participation from weaker players. Total effort can be increased as long as the positive effect of multiple prizes on participation can compensate for the discouragement effect on stronger players.

> *Observation* 4.1. Splitting the designer's budget into multiple prizes increases total effort in a sufficiently heterogeneous contest. The optimal number of prizes and the size of the budget allocation among the different prizes depend on the level of heterogeneity among players.
>
> **Support.** Several papers examine the optimality of multiple-prize contests under particular distributions of player types. See, for example, Szymanski and Valletti (2005) for *L*, Krishna and Morgan (1998) for tournaments, and, for APA, Barut and Kovenock (1998), Glazer and Hassin (1988), Clark and Riis (1998a), Moldovanu and Sela (2001) and Cohen and Sela (2008).[26] Szymanski and Valletti (2005) assert that the effectiveness of increasing incentives by increasing the number of winning prizes depends on the distribution of strong and weak players. The authors consider a general Tullock CSF with three players and two prizes: the first prize and the second prize. When there are two strong players and one weak player, a single prize is optimal. However, when there is one strong player and two weak players, it is optimal to split the single prize into two prizes with the first prize being $(2 + r)/(2 + 2r)$ fraction of the total budget. Note that this fraction shrinks as the noise level r increases; at the limit case ($r = \infty$) of an APA, there is a single prize. Moreover, in their results, the second prize should never be larger than the first one. Liu and Lu (2017) explore the impact of the number of homogeneous and indivisible prizes on players' efforts. They consider an APA where players have private information on their costs. It turns out that the optimal number of prizes for maximizing the total effort and the expected highest effort are both larger than one but have an upper

[25] Sisak (2009) reviews the literature on multiple-prize contests.

[26] For an analysis of the optimal prize structure in contests, see as well Myerson (1981), Moldovanu and Sela (2006), Azmat and Möller (2009), Fu and Lu (2009), Möller (2012), and Chowdhury and Kim (2017) among others.

bound. Further, the expected highest effort maximization requires fewer prizes to be awarded in comparison with total effort maximization.

In line with the literature on rationing, too many prizes in a contest discourage stronger players, whereas too few prizes discourage weaker ones (see Dechenaux & Kovenock, 2011; Faravelli & Stanca, 2012). Instead of making all players compete for all available prizes, the designer can reserve some prizes for weaker players only, thus increasing the chance of weaker players being represented among the winners. Examples include job positions for differently abled candidates, additional grants for female scientists, or best paper awards for graduate students at a global conference. Such a provision is equivalent to a winning quota.

4.4.2 | Quotas

Quotas are arguably the most commonly practiced form of AA policy tools, especially in the contexts of educational subsidization and employee hiring. Yet, compared to other tools of AA, theoretical analyses of quota policies are not so common in the contest literature.

Observation 4.2.1. Quotas, as extra prizes reserved for disadvantaged players, can enhance total effort if there is competition among the disadvantaged players for the extra prize.

Support. Dahm and Esteve-González (2018) study a lottery where total effort can be enhanced by putting aside a portion of the total prize budget as an extra prize for disadvantaged players only. Then, similar to a quota, the contest must have at least one winner from the disadvantaged group. This particular prize structure thus excludes advantaged players from a part of the prize (the partial exclusion principle), and has the potential of increasing total effort when the heterogeneity level is intermediate and there are at least two disadvantaged players competing for the extra prize.[27] A similar prize structure in an APA is considered by Dahm (2018) and it turns out that, when there are two disadvantaged players and one advantaged player, it is always optimal to introduce an extra prize independently of the level of heterogeneity between groups. This outcome can be contrasted with Szymanski and Valletti (2005)s' finding that the total effort in a lottery with one advantaged and two equally disadvantaged players is maximized when the total prize fund is allocated over a first and a second prize in a 3:1 ratio. A second prize in Szymanski and Valletti (2005) cannot be awarded to the winner of the first prize. The extra prize in Dahm (2018), on the other hand, induces different incentives for the advantaged and disadvantaged players as both the extra prize and the main prize can be awarded to a disadvantaged player, but an advantaged player is eligible for the main prize only. However, the complete exclusion of the advantaged player from all prizes is never optimal. Ip et al. (2020) examine how the organizational response to gender-based quotas for managerial positions varies depending on whether women are actually discriminated against or not. In a laboratory experiment, they find that total effort in the quota treatment falls when female candidates are equally suited

[27] Fallucchi and Quercia (2018) analyze this model in the lab and find that the benefits of this AA policy can be undermined when participants can retaliate (see Section 5).

or less suited to their male peers on average, but do not face discrimination in the selection process. However, if they are equally suited to the male candidates and yet face discrimination in the selection process, then average effort rises in the quota treatment.

Numerous studies explore the effect of quotas in natural experiments thanks to quotas being an extensively applied mechanism for leveling the playing field, especially in college admissions, job promotions, and political contests.

Observation 4.2.2. Quotas (especially gender-based ones) enhance the participation of disadvantaged players (women) without a detrimental effect on total effort.

Support. Several experimental studies find a positive impact of quotas, especially gender-based ones, in laboratory task environments. Beaurain and Masclet (2016) randomly assign participants in the roles of employers and prospective employees and demonstrate that the hiring of women improved significantly under mandatory AA without any compromise in team performance.[28] A standard experimental design for studying willingness to compete makes all participants perform a real-effort task first under a piece-rate, then in a tournament, and finally asking the winners of the second stage tournament to choose between the two schemes in a third stage. A group of studies implements this design to examine the potential gains in women's competitiveness under a gender-based quota. Based on the findings of an experiment with this design framework applied to adolescent participants, Sutter et al. (2016) show that performance does not deteriorate under a gender quota and suggest implementing quotas (and preferential treatment) early on to eliminate gender gaps in confidence and performance later. Czibor and Dominguez-Martinez (2019) reveal that a quota at the intermediate stage of a dynamic tournament significantly increases female representation without harming overall performance. They indicate that women shy away from competition in the absence of a quota, but the performance gap between men and women disappears when half the winning positions are reserved for women. Consequently, the quota also results in a significant rise in women's selection into the tournament. Maggian et al. (2020) also use a similar design to investigate the optimal implementation phase of a quota in a dynamic tournament. Based on their findings, a quota implemented only in the first stage does not increase women's willingness to compete, but a quota exclusively meant for the second stage or for both stages increases competitiveness without a negative effect on performance. In both Czibor and Dominguez-Martinez (2019) and Maggian et al. (2020), however, the choice between the piece-rate and the tournament is preceded by feedback on first-stage tournament outcomes and cannot be claimed to be purely led by quota provision. Participants in Kölle (2017)'s experiment experience a team incentive in addition to the piece-rate and the tournament, and they choose between the piece-rate and the team incentive in the final stage. The gender quota is implemented for the treatment group in the tournament stage. However, they find effort and concealment, as well as the selection into teams, to be independent of gender and quota implementations.

[28]The employers are penalized if they fail to respect the quota requirements.

There is very limited empirical evidence that advantaged players reduce their effort or perform worse because of quotas. For example, Cotton et al. (2022) examine pre-college human capital investment through a field experiment that mimics university admissions in the United States. A sample of middle school and junior high students are monitored by their access to a website with practice materials; it turns out that disadvantaged students (based on race) use this website at more than twice the rate of their peers under the quota treatment than under the color-blind treatment. On average, test scores improve among the disadvantaged group, although students with lower learning costs shirk their effort provision. In a set of natural recruitment experiments conducted in Colombia, Ibañez and Riener (2018) indicate that the gender gap in application closes under an announced AA policy (in comparison to an AA policy that is disclosed only after the application stage). Moreover, the AA policy increases (reduces) applications from women (men) in areas with high (low) gender-wage gaps. The robustness in their design comes from the ex-post equality of information for all participants; that is, all participants faced the same incentive structure once they had already applied for a job, but only participants in the treatment group knew about it before deciding whether to apply their knowledge or not. Roy (2018) compares AA policies targeting financially disadvantaged students vis-á-vis socially disadvantaged students in a field experiment conducted among university students in India. The results imply a performance improvement when AA is rooted in a social disadvantage, but the discouragement effect sets in if AA is implemented based on a financial disadvantage.

4.4.3 | Reward sharing rule

Both Section 4.4.1 and Section 4.4.2 invoke ways of splitting the reward budget into multiple rewards to balance incentives in a heterogeneous contest. The prize values in both cases are ex-ante fixed. A contest can also serve as a mechanism for allocating the available reward budget among the players, rather than as a way of choosing one or more winners. The total reward budget can be shared equally among all players or in proportion to players' efforts.

> *Observation* 4.3. A reward scheme that distributes the reward according to the share of a player's effort in total efforts can be preferable to providing balanced incentives in a heterogeneous contest.

> **Support.** Palomino and Sákovics (2004) rationalizes the performance-based revenue sharing scheme of the European Leagues in contrast to the egalitarian sharing of the U.S. Leagues by their respective competition structures. There being multiple national leagues in Europe competing for TV broadcast revenue, it is in the interest of each national league to incentivize domestic teams to bid high prices for star players. The only way the leagues can affect the teams' bidding incentives is through the TV revenue sharing scheme. Palomino and Sákovics (2004) argue that the leagues can do better with performance-based revenue sharing as compared to an egalitarian sharing or a winner-take-all scheme.[29] This is because an egalitarian

[29]Chang and Sanders (2009) show that the pool revenue sharing scheme, as practiced in Major League Baseball, for example, works as a winning tax and a loser subsidy, thereby generating a discouragement effect, which negatively affects total effort in the league. Each team under this scheme contributes a certain percentage of their locally generated revenue into a common pool, which is then redistributed equally to all participating teams.

scheme will fail to incentivize the teams to bid high for star players; on the other hand, a winner-take-all scheme will lower the level of competition by creating a large incentive gap between the teams that get star players and other teams that do not. However, if the league winner has a higher revenue share, then all teams have an incentive to play well whether or not they obtain a star player, and also to bid high for star players who increase their winning probabilities ex-ante. Findings from a randomized control trial (Singh & Masters, 2020) conducted among salaried childcare workers in India are relevant in this context. Instead of rewarding only the top performers, dividing the reward budget among all workers in proportion to the measured gains in their respective service outcomes improves child health indicators. These gains were induced by better performance among the lower-ranked workers under the proportional reward scheme and were sustained over time. Interestingly, this result contrasts with the finding in Cason et al. (2020) where winner-take-all contests produce greater total effort compared to proportional-prize-contests in a laboratory contest experiment with homogeneous players. In a heterogeneous setup, the increased chances of receiving a reward help to eliminate the discouragement effect among lower-ranked players.

4.4.4 | Prize allocation in dynamic contests

We know that dynamic contests may create asymmetric incentives, even for homogeneous players, to begin with, as previously discussed in Section 3.1. A player's interim success may increase his/her continuation value (the expected value from continuing to play) relative to the other player(s). If the higher continuation value is due to a greater probability of winning the final contest, then it is a case of "strategic momentum." If, on the other hand, the higher continuation value is simply due to a higher confidence level, then it is called "psychological momentum." Mago et al. (2013) distinguish between strategic and psychological momentum in a best-of-three contest. The strategic momentum results from equilibrium play, while the psychological momentum implies greater effort in the following round by the winner of a given round. In a laboratory implementation of the best-of-three lottery, they introduce an intermediate prize to capture the effect of the two momenta and vary the noise in effort impact. They report evidence against psychological momentum and conclude that subsequent heterogeneity in effort is primarily driven by strategic momentum.

Observation 4.4. A balanced redistribution of the prize budget over the course of a dynamic contest can mitigate the asymmetric incentives arising out of intermediate outcomes.

Support. When a dynamic contest is organized as a sequence of simultaneous-move component contests, and winning the entire contest requires winning a certain number of component contests before any of the other players does, the discouragement effect arising from the outcomes of the component contests in the initial phase can make some of the subsequent contests trivial (see Section 3.1). Introducing separate intermediate prizes for each of the component contests can make them non-trivial (Konrad & Kovenock, 2009). The laggard can then catch up with a positive probability. However, in the special case with ex-ante homogeneous players and constant prize value across all component contests, the laggard never has a higher expected effort than the leader. Clark and Nilssen (2018) shows that the opposite is possible when the dynamic structure of the contest is such that the net number of wins at any arbitrary point in time does not affect the continuation values, but rather serves as a head start. This ensuing head start may reduce effort over time due to the discouragement effect on both the leader and the laggard. In a simple two-period tournament, Casas-Arce and Martínez-Jerez (2009) indicate that effort in the second period assumes an inverse U-shape with respect to the first-period output. They mention that this "∩-shape is exaggerated with heterogeneity because confidence of leaders and demotivation of laggards arise earlier" (Casas-Arce & Martínez-Jerez, 2009, p. 1313). Based on empirical analysis of retailers' performance in dynamic sales contests in a commodities company, they argue that interim rankings in a tournament may serve as important signals of heterogeneity, even when initial achievement targets are set according to the size of the respective retailers (preferential treatment). They indicate that the leading retailers significantly reduce their sales efforts and lagging retailers increase their sales efforts unless they are far behind regarding interim performance. Later, in a model of dynamic tournaments, Klein and Schmutzler (2017) agree that a larger gap in the interim performance reduces effort in the second period. To mitigate this problem, they suggest redistributing the entire prize budget to the second period and increasing weight on first-period performance for the final evaluation.

Players can also be asymmetric, to begin with, in which case the contest outcome in the earlier stages of the dynamic contest may reinforce such heterogeneity or become pivotal depending on the winner's identity. Using data from Davis Cup matches between 2003 and 2015, Iqbal and Krumer (2019) show that an intermediate prize in the form of additional ranking points significantly reduces the gap between the share of wins between the competing favorites from the leading and lagging teams. In the Davis Cup, there are a maximum of five separate pairwise matches between individual players from two national teams. By design, the competition is tougher in Match 4. From 2009 onward, players would receive individual ranking points for winning single matches. Using this variation, the authors reveal that before 2009, a favorite from a leading team was more likely to win Match 4 than the favorite from the lagging team. This gap in winning probabilities became insignificant after the introduction of ranking points for every single win.

Clark and Nilssen (2020a) model a two-period APA where one player has a head start to begin with (asymmetric θ_i in the effort impact function) and the first-period winner gets a head start in the second period. The authors show that the optimal policy in such a scenario is to allocate the entire reward budget to the first period, effectively canceling out the second-period contest. They reconsider this problem of allocating a fixed reward budget over several rounds in Clark and Nilssen (2020b). Here, the players differ in their ability (asymmetric α_i in the effort impact function) and how ability increases further due to an early win. The optimal allocation of the reward budget for the two-period contest depends on the level of ex-ante heterogeneity. For a large degree of heterogeneity, the optimal policy is to allocate the entire budget to the first period, just like the scenario with the head start advantage in Clark and Nilssen (2020a). For an intermediate level of heterogeneity, total effort is maximized when the entire reward budget is allocated to the second period. In the case of small ex-ante heterogeneity, an equilibrium total effort as high as the reward value (full rent dissipation) is achievable when the competition can be organized over a longer sequence of contests. This result, however, also requires that the increment in ability, consequent to an early win, be sufficiently higher for the ex-ante disadvantaged player.

4.5 | Mechanism 5: Budget and caps

The use of caps on effort to level the playing field can be interpreted as limiting the budget $\overline{e_i}$. This is especially common in electoral contests in which campaign spending is often capped. However, Fang (2002) shows that caps never result in a higher aggregate expenditure in an *L* compared to no-intervention. The reason behind this is that although limiting any arbitrary player's effort improves the winning probability of the weaker players, it reduces total effort by depressing the efforts of all the stronger players.

Observation 5. An effort cap does not increase total effort in an *L*, but can increase total effort in an APA if the players are sufficiently heterogeneous and the cap is not too restrictive.

Support. Che and Gale (1998) reveal that, contrary to common sense, caps on spending may increase aggregate expenditure. In particular, if the cap is no less than half the valuation of the low-value player, then both players in an APA have mass points at the cap. Similar results were obtained by Gavious et al. (2002) for a two-player APA with incomplete information and convex costs. Kaplan et al. (2002) and Kaplan et al. (2003) consider APA with incomplete and complete information, respectively, where caps can be exceeded at a higher cost and it turns out that a cap always lowers the aggregated bids. Kaplan and Wettstein (2006) indicate that such flexible enforcement invalidates Che and Gale (1998)'s outcome, but their argument is refuted by Che and Gale (2006) who explain that caps may indeed increase expenditure when players have heterogeneous costs of lobbying.

Che and Gale (2003) demonstrate that under heterogeneous abilities, the expected profit of the contest designer is maximized by handicapping the most efficient player with a cap on the prize. Pastine and Pastine (2010) consider a lobbying contest where the concerned politician has a preference ordering over two competing policies. In an APA framework, they show that a more restrictive cap always reduces lobbying expenditure, even though the initial imposition increases lobbying expenditure if the politician slightly prefers the low-value lobbyist. The same authors suggest that a cap that is too restrictive on campaign spending in a political contest where one player has an incumbency advantage always reduces expected campaign spending (Pastine & Pastine, 2012a). Szech (2015) shows that maximization of aggregate expenditure calls for a less restrictive cap and a rather deterministic tie-breaking rule favoring the low-valuation player, replacing the symmetric tie-breaking rule of Che and Gale (1998).

Surprisingly, there is very little applied research with either laboratory or field data on the effectiveness of caps. An exception is Llorente-Saguer et al. (2018) who study, in the lab, the impact of bid caps and tie-breaking rules on effort in a two-player APA. The authors find that the optimal combination of these two policies in particular encourages the weaker player (more than predicted by theory). In addition, aggregate effort increases more under mild caps than under strict caps independently of the tie-breaking rule. In a recent experimental study, Baik et al. (2020) argue that in symmetric contests, overall effort shows a concave response to players' budget. They explain this concave shape with the diminishing marginal utility of winning induced by a high budget. This may imply that a contest designer can be better off by introducing a cap on effort, even in a symmetric contest, when the players are sufficiently wealthy.

4.6 | Mechanism 6: Miscellaneous mechanisms

Each of the above mechanisms considers modifying one element in the expected utility (Equation (5)) of the player. However, one element can mean more than one parameter. For example, modifying the reward structure is possible either by perturbing the CSF p_i or by revising v_i. In practice, it still amounts to playing only with the reward aspect, without affecting players' effort cost or abilities. Nevertheless, it is possible for the contest designer to simultaneously modify more than one element of the contest. In Section 4.6.1, we outline studies that compare two or more of the abovementioned mechanisms. There also are ways to level the playing field without altering one of the parameters in Equation (5). A prominent example is manipulating information in a contest, which is addressed in Section 4.6.2.

4.6.1 | Comparison and combination of multiple mechanisms

Mealem and Nitzan (2016) review the literature on Tullock contests (Equation (2)) with two heterogeneous players and a designer who can use three of the mechanisms seen so far when deciding the winner: changing the prize valuations through a tax; choosing the accuracy level r; and biasing the effort impact function either multiplicatively or additively. If the designer can choose only one mechanism to maximize total effort, modifying the prize valuations through an additive tax is optimal when the level of heterogeneity is high enough. With low heterogeneity, choosing the optimal noise level r is the designer's preferred tool. When the designer is allowed to combine the two mechanisms, two different optimal combinations allow for increasing effort up to $\frac{1}{2}(v_1+v_2)$. The first one combines the optimal multiplicative bias with the optimal level of noise: either $r=2$ or $r=\infty$ (Epstein et al., 2011, 2013). The second one combines the optimal modification of valuations through an additive tax and the optimal level of noise: either $r=2$ or $r=\infty$ (Mealem & Nitzan, 2014). Franke et al. (2014) conclude that total effort could reach v_1 by combining the optimal level of noise $r=\infty$ and an optimal combination of multiplicative and additive bias.

Bodoh-Creed and Hickman (2018) use the contest setting of large contests from Olszewski and Siegel (2016) to model a structural competition between a continuum of heterogeneous students with unobservable cost types for enrollment in a continuum of heterogeneous colleges. They find that both quotas and additive biases for minority groups achieve equivalent outcomes in terms of diversity in colleges and students' effort (human capital) decisions. However, their most interesting finding is the impact on the final distribution of efforts. The players with the highest ability in the disadvantaged (advantaged) group reduce (increase) their effort, and the players with intermediate and low ability increase (decrease) the same. Not applying any AA policy induces pre-college minority students to reduce effort; consequently, they are allocated to the worst colleges.

Balafoutas and Sutter (2012) study the effectiveness of quotas in comparison to a weak and a strong additive bias in a real effort contest experiment. They find quotas to be equivalent to the weaker additive bias. They also consider the policy of repeating the competition until a player from the disadvantaged group wins. This results in a weaker effect. In a similar task environment, Balafoutas et al. (2016) compare the within-subject effectiveness of gender-based quotas to that of arbitrarily allocated quotas. They also elicit participants' preferences for these two types of quotas. In line with theoretical expectations, they find that most of the advantaged (disadvantaged) participants vote against (for) quotas when voting does not have a cost. In contrast, the majority of participants from both groups abstain from voting if voting is costly. Individual performance in the real effort task is not affected significantly under the gender quotas, but the advantaged (disadvantaged) group increases (decreases) its performance under the random assignment quotas.

4.6.2 | Information manipulation

The information available to players about different aspects of the contest has a relevant impact on their incentives to compete. There are not very many theoretical studies on how the availability of different types of information regarding the contest may affect player strategies. Drugov and Ryvkin (2017) present their findings for both private and public information settings. In most real-life situations, however, participants lack full information about one or more elements of the contest. Below, we summarize the findings about the availability of information regarding players' abilities, the number of winners, and players' identities.

- *Players' abilities*: Fu et al. (2014) consider a multi-prize APA where players' types, modeled by higher or lower effort costs, are privately observed. Only the contest designer learns about all the players' types and chooses whether to disclose or conceal this information before the types are realized. It turns out that concealing such information results in higher expected total effort, regardless of the distribution of abilities. However, in a two-player contest with a single prize and a Tullock CSF, Serena (2021) finds that full disclosure brings higher expected total effort than full concealment if the distribution of types is skewed toward strong types. When the designer has the flexibility to disclose players' types contingent upon realizing them, the optimal policy is to disclose the players' types only when both players are strong.
- *Number of winners*: Balafoutas and Sutter (2019) experimentally compare two environments—one with uncertainty about the number of winners and another with ambiguity about the number of winners— to a full information baseline. The participants in their experiment exhibit greater willingness to compete under uncertainty. Moreover, men have a higher success rate than women in both treatment environments. Gee (2019) report contrasting evidence based on data from a very large field experiment where the intervention determines whether or not the job applicants observe the number of applicants for a given job

opening. It turns out that when applicants have this information, they are more likely to complete an application.

- *Players' identities*: Identity is often a strong trigger in competitive situations. Chowdhury et al. (2016) present experimental evidence that efforts increase significantly when the identity of the opposition group is revealed in a contest between East Asian and Caucasian participants. Such an increase in the intensity of competition may reinforce existing discrepancies in achievement. Players' identity information can also bias the contest designer's preferences and the umpire's or judge's verdict. A blind AA conceals sensitive information (e.g., gender, race, nationality) about players in competitive settings.[30] Thus, when deciding the winner(s), the evaluator(s) can only observe their merits that are relevant to the competition, thus encouraging meritocracy. On the other hand, this can also encourage diversity by eliminating race-based discrimination (Becker, 1957).[31] However, this conclusion might not apply in contexts where minorities are disadvantaged for reasons other than race-based discrimination. In the following, we outline the literature where the contest designer implements a blind AA policy with the aim of increasing diversity. In a hiring process with statistical discrimination, Lundberg (1991) compares a blind AA policy with an alternative AA policy that allows the employer to observe all the attributes of the workers but requires offering equal compensation to workers with the same observed score. There is a trade-off between efficient investment in human capital and the efficient allocation of highly skilled workers to top jobs. While workers' incentives are equalized under the blind AA policy, the efficient allocation of jobs requires more information, which is achieved via the alternative AA policy. Chan and Eyster (2003) obtain similar results for a college admissions office that values both students' academic qualifications and diversity. When an identity-based AA is banned and there is a blind AA policy, an admissions office interested in promoting diversity may partially ignore the candidates' qualifications and end up admitting relatively substandard candidates in comparison to the candidates they would admit under an identity-based AA. Fryer Jr et al. (2008) obtain the same conclusion with an empirical analysis of matriculates at seven elite colleges in the United States in 1989. Similarly, Fryer and Loury (2005) consider the desirability of ex-ante and ex-post subsidies for an identity-based and a blind AA policy. Note that the ex-ante subsidy can be interpreted as a head start while the ex-post subsidy will be more comparable to a handicap. They find that a handicap (ex-post subsidy) is preferable in an identity-based AA, while a blind AA should involve a head start (ex-ante subsidy) that allows a large proportion of players to exert zero effort. Sethi and Somanathan (2018) consider a social planner whose objective is to select the most skilled performers, regardless of diversity. Whereas players' performance depends on ability and costly training, the social planner only observes training and player identity. In such a situation, a blind policy is not always optimal. When training is heavily resource-dependent, the optimal policy has different training thresholds for different groups. Finally, it is also possible to increase total effort by matching players using their biological identities. In a two-player lottery experiment, Brañas-Garza et al. (2019) match participants according to their prenatal exposure to testosterone (measured through the second to fourth digit ratio). They find that matching two highly exposed male participants results in the highest level of total effort in comparison to any other match.

[30]It is often coined as "color-blind" in popular media due to the use of race in U.S. policies.

[31]For example, in auditions for candidates to join symphony orchestras, the use of physical screens to conceal candidates' identities has significantly increased the probability of hiring female musicians (Goldin & Rouse, 2000).

However, such contest designs rooted in biological identity might not be feasible due to legal and logistical reasons.

5 | CAN AFFIRMATIVE ACTION INDUCE NEGATIVE REACTIONS?

Favoring one group over another can sometimes induce the members of the non-favored group to retaliate through sabotage, which refers to foul play or costly actions beyond the rules of the game that reduce the probability of one's opponent(s) being successful (Chowdhury & Gürtler, 2015).[32]

Brown and Chowdhury (2017) find, theoretically and empirically, that the increment of total effort under policies for leveling the playing field can be counterproductive because sabotage increases in the presence of these policies. An even more disturbing consequence has been reported by Girard (2021). Using a difference-in-differences analysis, the author shows that the number of murder attempts against lower-caste representatives in India rises significantly in the aftermath of the implementation of a caste-based electoral quota. Likewise, Iyer et al. (2012) find that increased female representation in local governments in India induces a significant increase in crimes against women. Both studies use state-level variation in the execution of political reforms as their identification strategy, and run robustness checks to show that these increased attack rates are not due to general envy, but occur in reaction to AA policies.

Chowdhury et al. (2022) experimentally examine the impact of the introduction and repeal of a head start and a handicap policy on the provision of effort and sabotage. A high-ability participant and a low-ability participant are matched to compete against each other for a prize in a real effort task. An additive bias reducing the performance gap between them is either introduced only in the second half of the experiment, or at the very beginning of the experiment and repealed after the first half. They find that AA has no positive effect on effort provision. However, the effect of AA on sabotage activities depends on whether the participants have experienced the environment without AA in the past; if the participants start competing in an environment where AA exists, to begin with, then there is less sabotage in treatments with AA than without. The introduction of AA in the middle of the experiment induces an increase in the sabotage exerted by the low-ability participants under the handicap, whereas the repeal of the AA (especially the head start) increases the sabotage by both the high-ability and low-ability types. Based on experimental implementation of quotas in both the field and laboratories (Banerjee et al., 2018; Chowdhury & Gürtler, 2015; Fallucchi & Quercia, 2018; Leibbrandt et al., 2018; Petters & Schröder, 2020), there is mixed evidence about the impact of quotas on sabotage, spite, and unethical behavior targeted at participants who benefit from AA. Maggian and Montinari (2017) fail to observe any significant effect of gender quotas on unethical behavior in a laboratory real effort task.

[32]In sports, sabotage is considered an unsportsmanlike behavior and is usually penalized. In a context without AA, Balafoutas et al. (2012) find that reducing the penalties or costs of committing sabotage in the Judo world championship increases the observed sabotage; in addition, stronger players are the most common targets of saboteurs.

6 | CONCLUSION

Contests are important features of life. In various contests, however, the players may have heterogeneous abilities, making the contest less competitive and the outcome more favorable for stronger players. Numerous policies are employed to counter this situation and to provide competitive balance in the contest. Such policies include AA policies, which are based on ethical reasoning. In this survey, we covered the contest-related literature on mechanisms aimed at leveling the playing field, with a focus on AA policies.

AA policies favor certain demographic groups, commonly called minority or disadvantaged players, who are under-represented in the socio-economically dominant sections of society. The members of these minority groups may bear a disadvantage that weakens them in competitive environments and causes their under-representation. AA policies are aimed at enhancing diversity in competition outcomes and equalizing opportunities among all members of society. These policies are widely implemented worldwide. Nevertheless, their effect on competition incentives is still unclear, which harms public support for these policies.

The literature indicates that too much asymmetry among players causes incentive problems that reduce overall effort (Section 3). Weaker players have lower expected payoffs and lower incentives to invest effort in the contest. If players are highly heterogeneous, even the strongest player is discouraged due to the decline in the expected intensity of competition. This dual incentive problem to compete is known as the discouragement effect and can be mitigated by policies that level the playing field. Such policies, including AA, can enhance competition by equalizing the ex-ante success probabilities across heterogeneous players, either by weakening advantaged players (the handicap) or strengthening disadvantaged players (the head start).

A major purpose of this survey is to compare and contrast different mechanisms to implement policies (including AA) that aim to level the playing field while not harming overall effort. In particular, we have examined how a designer can level the playing field by selecting the contest rule (Section 4.1), introducing an additive or multiplicative bias to the effort impact function (Section 4.2), biasing the players' valuations of the prize or modifying the effort costs (Section 4.3), altering the reward structure (Section 4.4), restricting effort with a cap (Section 4.5) or by adopting other miscellaneous mechanisms (Section 4.6) such as manipulating information. The summarized theoretical results characterize the optimal conditions under which all these AA mechanisms can be used by policymakers to increase both diversity and total effort. Although this survey provides an assessment to policymakers on how to implement a wide range of AA mechanisms, it does not contemplate a thorough analysis of other important factors that may influence the success or failure of such policies. For example, information about players' abilities and progress can be concealed to mitigate the discouragement effect (Section 3). Sensitive information about players can be concealed when selecting the winner (Section 4.6.2), and role models can provide signals to high-ability minority players about their expected probabilities of succeeding (Chung, 2000). Another relevant factor that may arise with AA is the incentive to sabotage advantaged opponents (Section 5).

After reviewing the theoretical and empirical literature on AA and related mechanisms, we have identified several future research questions to shed more light on the debate. As a general note, all the mechanisms we consider here largely build on the APA and Tullock contest models, whereas the tournament framework remains scarcely studied in the literature. Examining similar policies in a tournament framework may generate new insights about the implications and effectiveness of the different mechanisms, and help scholars form conclusions about the generalizability of the different policy outcomes observed with APA or Tullock.

Heterogeneity within the population of weaker players is understudied. The related issue of ethnically aimed policies, in a situation where stronger players may exist within the weaker ethnic group, is not thoroughly investigated either. Another tricky question is which collectives should be prioritized for AA in multi-ethnic and multiracial populations. As Sowell (2004) highlights, there are different disadvantaged groups competing for the benefits of AA, and there is the risk that the most disadvantaged members of society do not receive such benefits. Among the black student population in the United States, for example, students of African and West Indian origins have significantly higher representation compared to the descendants of African-American slaves. Massey et al. (2007) find that the immigrant and native black students do not differ significantly in terms of grades and performance once admitted. However, the immigrant students exhibit a greater drive to get in and have higher parental qualifications. Uniformly applying a color-based AA policy can therefore lead to a meritocracy within the people of color. Fryer Jr and Loury (2005) note that, under certain circumstances, AA can yield even inferior outcomes for many of the disadvantaged players than a situation without the AA.[33] In addition, there is heterogeneity not only between groups, but also within groups; this can be used to target different beneficiaries of AA.[34] We are not aware of any model in contest theory considering the interaction of more than two population groups. However, it would be reasonable to assume that different collectives have different optimal mechanisms to enhance their representation. Moreover, competition among ethnic groups is usually multi-dimensional. The majority population and minorities in society, for example, engage in unequal competition on multiple fronts, including educational performance, political participation, and rights over practicing religion and languages. Avrahami and Kareev (2009) show that the weaker players, in a multi-battle contest between heterogeneous players, give up on many fronts so that they can make optimal use of their limited resources on the remaining fronts.

Another scope for future research is the long-term evaluation of AA policies and the influence of policymakers over the duration of AA policies. Most AA policies seem permanent instead of temporary. To our knowledge, only Chowdhury et al. (2022) investigate the effects of implementation and removal of head start and handicap policies in different time periods. Sowell (2004) suggests that AA feeds and is fed by conflicts between social groups, especially in countries where political parties are perfectly classified by ethnic groups. Although there are some dynamic models that study AA, more research is needed to evaluate their long-term effects (Bodoh-Creed & Hickman, 2018), and the requisite political conditions to sustain AA policies in case they have positive long-term outcomes. As far as we are aware, only Chan and Eyster (2009) consider political preferences over AA in their analysis of how both income inequality and the level of competition for college admissions influence the median voter's support for diversity and AA policies in education.

There is also scope for future work to investigate the responses to AA mechanisms that level the playing field with different impacts on participation and aggregate effort. The theoretical findings clearly suggest that AA mechanisms in more deterministic contests (the APA being the most deterministic contest) seem to achieve the maximum levels of aggregate effort by reducing

[33] In a three-player APA with incomplete information and possibly non-linear heterogeneous costs, Kirkegaard (2013) shows that handicapping the strong player may result in the medium player becoming more aggressive, and the weak player getting hurt, even to the extent of staying out of the contest.

[34] For example, Espenshade et al. (2004) notes that U.S. universities use not only SAT scores and race to admit students but also other characteristics such as their athletic ability, and give preference to the children of alumni. They find empirical evidence indicating that admissions bonuses for athletes have been growing over time, whereas bonuses for minority applicants are steadily declining.

participation to the minimum (two players, or even just one player). Aggregate effort in less deterministic contests (e.g., the lottery contest), on the other hand, is driven by wider participation. These contrasting outcomes can be studied experimentally and empirically. Understanding the effectiveness of leveling the playing field in dynamic contests can also benefit from experimental and empirical studies. Empirical studies about dynamically structured contests mostly use data from different sports tournaments. Studies evaluating the effect of AA policies on college admissions and performance are grounded in cross-section time-series data. Such data look at a sequence of contests among different representatives from the same social groups. The same players often face each other in a sequence of contests with different structures and reward values. These could be interesting topics for future research. See Konrad (2009, Ch. 8) and Konrad (2012) for more topics in dynamic contests.

The final concern is the legal and logistic implementation of AA mechanisms in terms of concrete policies. For example, it may be easy to implement an AA policy when ability differs strictly along a social identity dimension (e.g., gender, race, nationality) due to historical reasons. For the case of female underrepresentation, for example, Niederle and Vesterlund (2011) review empirical and laboratory studies on women's lower probability of entering competitions and compare different AA policies that target women.[35] However, their conclusions might not be generalized to other minority groups with different distributions of characteristics, different shares of the population, and different determinants of their underrepresentation. When heterogeneity in ability does not correspond sufficiently to a social identity demarcation, implementing AA with the objective of enhancing diversity may appear logistically challenging. Identifying the target group is harder. Ethical and political justifications of policy decisions may also be less obvious. There is a dearth of investigation in this area, with two prominent exceptions (although with non-standard contest models) by Fryer Jr and Loury (2013) and Krishna and Tarasov (2016).[36] Whereas literature outside the contest research attempts to progress in this area, the framework of contests could complement these findings and pursue other remaining unanswered research questions on AA.

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[35]Niederle and Vesterlund (2011) explain some AA policies not studied in our survey, such as the role of feedback when information is incomplete, stereotypical female and male efforts, the gender composition in team competitions, and the role of risk aversion. Another AA policy not analyzed in this survey is the gender composition of decision panels (Bagues et al., 2017).

[36]Fryer Jr and Loury (2013) consider a two-stage game in which players first invest in their own skills and then compete for a job. When identity-based AA is possible, then implementing AA in the recruitment process is efficient. However, when such identity-based AA is not possible and a majority of the players have lower skills, support in skills development is more efficient. Krishna and Tarasov (2016), however, consider ability to be a combination of nature and nurture, that is, derived from birth as well as further investments in improving abilities. With heterogeneity being an inborn ability, the authors indicate that when the cost of accumulating skills is high, then an AA policy may be more socially efficient than when it is low.

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