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ABSTRACT

Fake News

In the last decade, social media and the Internet have amplified the possibility to spread false information, a.k.a. fake news, which has become a serious threat to the credibility of politicians, organizations, and other decision makers. This paper proposes a framework for investigating the incentives to strategically spread fake news under different institutional configurations and payoff structures. In particular, we show under what conditions institutions that foster transparency in the media cause more fake news. Complementary, we study what kind of environments are particularly susceptible to the production of fake news.

JEL Classification: D72, D8, H0, L1

Keywords: campaigning, electoral competition, signal jamming, vertical product differentiation

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Fake news spread on social media is one of the "biggest political problems facing leaders around the world", says Jim Messina, a political strategist who has advised several presidents and prime ministers.

[The Economist, November 4th, 2017, p. 21]

1. INTRODUCTION

In the quest for improving political prospects, increasing sales figures, and influencing decision makers, there seems to be a tendency to strategically spread false or partially false information, a.k.a. "*fake news*". In political elections, fake news are spread to move outcomes in a favored direction (Kang, 2016; Beck and Witte, 2017; Sanger, 2017),[1] there are fake product reviews on internet forums to increase sales (Harmon, 2004; Mayzlin *et al.*, 2014; Zinman and Zitzewitz, 2016), lobbyists make up fictitious arguments to steer a decision makers' policy, and workers spread false information to improve their career prospects (Duffy *et al.*, 2002; Murphy, 1992, note 4). Oftentimes, such fake news are associated with bad decisions by the audience that is targeted. While the phenomenon is prevalent and occurs in seemingly unrelated environments, it is still poorly understood which environments and institutional configurations aggravate incentives to create fake news or how to design an environment that reduces fake news intensities.

This paper provides an overarching framework to investigate the incentives to create fake news in different environments and under different institutional configurations. In this framework, we focus on two questions. First, we study how the environment influences incentives to create fake news. That is, we seek to gain insights on whether politicians create more fake news in presidential or parliamentary elections, whether firms rely more heavily on fake news if price competition is fierce or if demand is insensitive to prices, and whether workers create fake news to impress their superior rather if they have the chance to become the boss of their team or an alternative unrelated team. Second, we study how institutions (e.g., a public agency) that aim at fostering market transparency by reducing fake news and other informational distortions in the media affect players' incentives to create fake news. In par-

[1] See, e.g., Shane (2017) and Sanger (2017) on Russian fake news to influence the 2016 presidential election in the US, Kang (2016) and Hsu (2017) on fake news websites that accused a pizza restaurant of being the home base of a child abuse ring led by Hillary Clinton and her campaign chief, John D. Podesta, and Beck and Witte (2017) and Oltermann (2017) on dirty campaigning via fake news during the Austrian election 2017.

ticular, we investigate whether more rigorous institutions might even end up in boosting the overall amount of fake news.

To represent common features of most environments in which fake news occur, we develop a two-stage setup with an audience and two individual players. At the first stage, the audience observes a quality signal about each player, which summarizes information from newspapers, television, the Internet, and other media. While the signal is partly informative, players may manipulate its content by the costly creation of fake news, e.g., by hiring a blogger who posts on the Internet. To enable a comparison of different environments and institutions, at this stage we employ a standard Bayesian updating framework with normally distributed beliefs, which is well-known from economics (e.g., Prendergast and Stole, 1996; Meyer and Vickers, 1997; Holmström, 1999) and marketing (e.g., Erdem and Keane, 1996; Mehta *et al.*, 2003; Janakiraman *et al.*, 2009; Goettler and Clay, 2011). At the end of the first stage, the audience updates its beliefs about the players' qualities against the background of the observed – and possibly manipulated – quality signals. In the following, we will refer to the player with the higher posterior expected quality as the *quality leader* or the player that has a *posterior lead*.

At the second stage, players participate in a competition for which the obtained reputation from the first stage is relevant. We capture the two leading cases that players either only care to obtain a better reputation than their respective opponent or that they are interested in the margin of their lead. Therefore, we distinguish between two classes of payoff functions. First, we analyze a setting that induces constant payoffs, i.e., the player with the posterior lead wins a fixed high prize whereas the other player only receives a fixed low prize. By means of a number of applications, we show that this payoff structure is an idealized representation of numerous themes in different strands of the literature. In electoral competitions, it reflects the payoff structure of presidential elections where the winner receives a fixed amount of power that does not depend on his margin of victory. In consumer goods markets, it depicts a market populated by price-insensitive consumers who all buy from the quality leader. In personnel economics, the constant payoff structure resembles a promotion tournament whose winner receives a fixed wage increase, which mirrors internal labor markets with wages being attached to jobs.

We contrast these environments with their counterparts that give rise to a payoff structure in which both players care about the magnitude of the posterior lead. Again, we make use of a number of applications to show that such a payoff structure reflects the main aspects of those environments that are the natural counterparts to the environments with constant payoffs. In parliamentary elections, a larger margin of victory of the winner is payoff relevant due to constitutional super majority requirements for some policies or further veto players (Fishburn and Gehrlein, 1977; Grossman and Helpman, 1996). In consumer goods markets, firms often face rather price-sensitive consumers, which results in a price competition for which the degree of vertical product differentiation is crucial, as for example in Shaked and Sutton (1982). Finally, after a promotion tournament it is sometimes essential for the promoted worker to have a high expected talent relative to his opponent as this might result in more respect, less arguing and, thus, lower opportunity costs of time when enforcing (maybe unpopular) decisions at the new job. The parsimony of our approach allows us to embrace both kinds of payoff structures in one setting.

Our first set of results compares equilibrium fake news intensities for a constant payoff structure with those for a payoff structure that depends on the magnitude of the posterior lead. Which payoff structure implies more fake news is an obvious question of interest not only because both payoff structures are frequently observed, but also because the shape of payoffs is often at the discretion of a superior organization – the form of election is determined in constitutions, and firms configure their promotion policies. We show that the effect of the payoff structure on fake news intensities crucially depends (i) on whether incentives of the two players at the second stage are rather aligned or misaligned in the setting where payoffs are based on the posterior lead, and (ii) on the initial degree of player heterogeneity in terms of the magnitude of the *prior lead*.[2]

There are two main cases to be distinguished. First, suppose that in the setting where the posterior lead is relevant for payoffs both players benefit at the second stage if this lead is large. In this case, we show that a player will create more fake news in this setting than under a constant payoff structure if and only if he enters the game with a substantial prior lead. To place this result into context, consider the example of two firms competing in prices at the second stage. If consumers are sensitive to prices, both firms will typically benefit from larger vertical product differentiation due to less intense competition (see Shaked and Sutton, 1982). In contrast, markets will reflect a constant payoff structure if consumers are insensitive to prices. In the context of price competition our result therefore predicts that firms with very strong brands, i.e., high prior quality expectations, invest more heavily in fake product reviews if consumers are price-sensitive. In contrast, we would expect firms with relatively lower prior quality expectations to produce more fake reviews in markets populated by consumers that are price-insensitive.

[2]We allow for players that already enter the first stage of the game with different expected qualities so that we have to differentiate between a prior lead and a posterior lead.

Second, suppose that players' incentives at the second stage are rather misaligned in the setting where payoffs are based on the posterior lead. In particular, both players benefit from a better relative reputation at the second stage no matter whether they have a posterior lead or not. Then, both players will create more fake news under a payoff structure where the posterior lead is relevant compared to a constant payoff structure if and only if their initial reputation is sufficiently different, i.e., one player enters the game with a substantial prior lead. An obvious example for the case with rather misaligned incentives at the second stage is a parliamentary election where an improved election result typically increases a party's number of seats in parliament irrespectively of whether it won the election or not. In contrast, a constant payoff structure reflects some basic properties of presidential elections where the winner receives a fixed amount of power. In this context, our results therefore predict that the amount of fake news is higher in a presidential election compared to a parliamentary election if and only if the race is close, i.e., when candidates start campaigning they face approximately the same chance to win the election.

Our second set of results describes how the intensity of fake news is affected by institutions that foster transparency in the media, i.e., institutions like public agencies that erase fake reviews or hinder the publication of faked statistics. While the overall shape of the institutional effect differs across payoff structures, we show that it can always be decomposed in two sub-effects. First, there is an *information effect* of institutions on fake news intensities. This effect captures that such institutions diminish the expected impact of fake news on the audience's quality perceptions. The direction of the information effect is independent of the specific structure of payoffs at the second stage. However, institutions against fake news also affect the anticipated payoffs from the competition at the second stage. Hence, there is a second effect, the *competition effect*. This effect crucially depends on whether payoffs are constant or based on the magnitude of the posterior lead.

First, consider a constant payoff structure. Here, the competition effect of more rigorous institutions will lead to an **increase** in fake news intensities if and only if players' initial heterogeneity is large. The intuition is as follows. If one of the players enters the game with a substantial *prior lead*, the winner of the competition is almost predetermined. Consequently, both players' incentives to create fake news are low. If, however, institutions become more rigorous in eliminating fake news, the audience will trust the received signals more strongly and use them more intensely to update its quality beliefs. From the perspective of the players, the outcome of the competition will then depend more heavily on the impact of chance. Therefore, it becomes less clear that the stronger player will win the competition, which restores both players' incentives to create fake news. Importantly, the competition effect will dominate the information effect for strong enough heterogeneity such that more rigorous institutions are only capable to reduce fake news intensities if players' initial heterogeneity is small.

Second, consider a setting where the payoffs depend on the magnitude of the posterior lead. In such a setting, incentives to create fake news are generally higher for the player that expects to win the competition. As a consequence, the sign of the competition effect depends on whether the player has a prior lead or not, which sharply constrasts with the constant payoff structure, where the competition effect works into the same direction for both players. If institutions against fake news become more rigorous, the information that the audience obtains will appear more trustworthy to it. Thus, the audience will take the signals more strongly into account. Chances of the initially trailing player to win the competition are then restored, which boosts his incentives to create fake news. In contrast, more rigorous institutions deteriorate the favorable starting position of the player with a prior lead. His probability of becoming the player with a posterior lead decreases, which reduces his incentives to create fake news.

Our paper studies the creation of fake news in a variety of environments. In particular, it contributes to the literature on electoral competition, consumer goods markets, lobbying, and human resource management, where the creation of fake news has not been a major topic so far. Concerning the literature on electoral competition, our approach is most closely related to papers that model reputation as the major determinant of elections (for an overview see Besley, 2005). In most of these papers, candidates choose to commit to a policy platform prior to the election and then get elected on the basis of the inferences that voters make from the observed platforms. There are two modeling approaches for the payoffs after the election. On the one hand, some authors choose to use a constant payoff structure – typically the winner takes all (e.g., Majumdar and Mukand, 2004; Callander, 2008). On the other hand, there are papers that use a payoff structure such that the margin of victory is essential for the payoffs after the election (e.g., Fishburn and Gehrlein, 1977; Grossman and Helpman, 1996). We consider our model of the second stage of the competition as a simplistic representation that captures this difference between the two approaches. By introducing a first stage where candidates can create fake news, our paper can therefore contribute to the analysis of political candidates' campaigning behavior across the two modeling approaches.

In consumer goods markets, we relate to the papers that study fake reviews on internet platforms. A number of papers establish convincing evidence that firms strategically spread fake reviews: Ski resorts over-report natural snowfall (Zinman and Zitzewitz, 2016), hotels post fake reviews on TripAdvisor (Mayzlin *et al.*, 2014), and book publishers and authors recommend their own work (Harmon, 2004). These studies do not only proof existence of fake news but also investigate which firms choose higher fake news intensities within a specific market. This approach has also been taken by the few theoretical papers that study fake product reviews. In particular, Dellarocas (2006) and Mayzlin (2006) show how the product's quality affects firms' decisions to manipulate reviews and what are the resulting consequences for consumer surplus. Our approach complements these papers as we do not study how fake reviews vary within a given market but rather how the global environment, i.e., the market structure, influences fake news. We thereby also aim at providing a new set of testable predictions for studies that set out to compare fake news intensities across different environments and institutional configurations.

Our paper also extends the literature on lobbying and rent-seeking contests by adding a first stage at which players can create fake news to improve their starting position in the subsequent rent-seeking contest. The seminal paper by Tullock (1980) considers a situation in which several lobbyists spend resources to convince a decision maker to implement their project. Tullock's model on lobbying has become the workhorse for a large variety of applied theory papers on rent-seeking contests, including litigation contests and electoral competitions (for an overview, see Congleton *et al.*, 2008a,b; Konrad, 2009). His model is also a subcase of the payoff structures that we analyze at the second stage. Our results therefore allow to shed light on the incentives for creating fake news in the different kinds of contests.

Finally, our paper is related to issues in human resource management. Workers can increase their incomes via better performance either by boosting their explicit incentive pay or by improving their career prospects. The work by Milgrom (1988) and Milgrom and Roberts (1988) has highlighted that workers might alternatively rely on influence activities if performance measures are subjective. Such influence activities comprise all counterproductive actions that lead to a kind of internal rent seeking in firms (e.g., brown nosing, bribing, or behaving as yes men; see Prendergast, 1993; Ewerhart and Schmitz, 2000; Gibbons, 2005). Our paper introduces the creation of fake news by workers among superiors, co-workers and customers for improving own career prospects as a new form of influence activity.

Technically, our paper is related to the literature on signal jamming, where one player chooses an unobservable action to influence the beliefs of other players (see, e.g., Stein, 1989; Meyer and Vickers, 1997; Holmström, 1999; Grunewald and Kräkel, 2017). In our context, the two players choose unobservable fake news intensities to manipulate the audience's beliefs about their qualities.

The paper is organized as follows. The next section describes a general two-stage model where two players choose fake news intensities at the first stage and compete at the second stage. Section 3 derives the solution to this general setting. Sections 4 and 5 analyze optimal fake news intensities under a constant payoff structure and under payoffs that depend on the magnitude of the posterior lead, respectively. Moreover, these sections show how institutions to foster transparency in the media affect players' decisions to create fake news. In Section 6, we analyze whether players' fake news intensities are larger if payoffs are constant or if they depend on the magnitude of the posterior lead. Section 7 concludes. All proofs are deferred to Appendix A.

2. THE MODEL

In this section, we present our basic model in which players are tempted to inflate their reputation by creating fake news. For this purpose, we consider a two-stage game between two risk-neutral players, A and B. At stage one, the players can create fake news in order to improve their reputation from an audience's point of view. At stage two, they enter a competition in which their attained reputation is of value. Our goal is to analyze fake news across a variety of different applications. Hence, the exact nature of the competition at stage two can take many different forms, e.g., electoral competition, price competition, or promotion tournaments.

We adopt a setting of symmetric quality uncertainty. Hence, no player has perfect information on the true quality of the two players q_i ($i = A, B$), which we assume to be distributed according to a normal distribution with mean $\bar{q}_{i0} > 0$ and variance σ^2_{i0}. This lack of precise information reflects that players' quality is often a matter of taste and therefore depends on their personal characteristics as well as the audience's preference. Alternatively, the quality uncertainty might arise because a player's performance could depend on the specific and uncertain matching of his personal characteristics and the requirements of his task.

At stage one, the audience observes a quality signal s_i about player i. Signal s_i represents, for example, information from newspapers, television shows, and online forums. On the one hand, the signal reveals information on the player's true quality, q_i, as his statements in the media enable the audience to partly infer his quality. On the other hand, the quality signal can be distorted for two reasons. First, players can endogenously manipulate the signal by creating fake news. Player i could, for example, hire a blogger to create positive fake news about himself on the Internet.[3] In the following, player i's fake news intensity is denoted by $f_i \geq 0$. Second, the quality signal can be distorted for exogenous reasons, as there might exist fake news that do not stem from the players' activities. For example, articles in the public press and on websites may involuntarily be based on erroneous information. Such exogenous distortions are captured by the random variable φ_i, which is assumed to be normally distributed with $\varphi_i \sim N\left(0, \sigma_\varphi^2\right)$.

One major goal of the paper is to study the impact of institutions (e.g., a public agency) that foster market transparency by reducing fake news and other informational distortions in the media. In particular, we are interested in whether such institutions will impede or may even aggravate players' motivation to create fake news. For this purpose, we model institutions in a reduced form. We introduce a parameter $\beta \geq 0$ that determines how strongly $f_i + \varphi_i$ affects the audience's quality signal:[4]

$$s_i = q_i + \beta \cdot (f_i + \varphi_i) \quad (i = A, B). \tag{1}$$

Hence, institutions in our setup do not discriminate between the different kinds of fake news. Lower values of β correspond to more rigorous institutions. In the limit case of perfectly rigorous institutions (i.e., $\beta = 0$), the audience receives precise information about a player's true quality q_i even if players create fake news. If institutions are represented by $\beta = 1$, in contrast, a player's true quality q_i and his fake news intensity f_i are perfect substitutes. Finally, if institutions are lenient, it might even be the case that fake news affect the quality signal more strongly than the underlying quality (i.e., $\beta > 1$).

Creating fake news, f_i, leads to costs $c(f_i)$ with $c(0) = c'(0) = 0$ and $c'(f_i), c''(f_i) > 0$ for $f_i > 0$, i.e., the more intense i invests in fake news the higher will be his costs.[5] The cost function is supposed to reflect various kinds of costs. In particular, spreading fake news may cause immediate costs for hiring a blogger or an organization but also delayed costs as fake

[3] As in the following each player's payoff is determined by the relative comparison of both players' qualities from the audience's point of view, it is not necessary to differentiate between positive fake news that positively influence own perceived quality and negative fake news that negatively influence the perceived quality of the opponent.

[4] Following the signal-jamming literature – e.g., Holmström (1999), Meyer and Vickers (1997), and Stein (1989) – we use a linear signal structure in our setting.

[5] An alternative approach to studying fake news would be to use a cheap-talk model a la Crawford and Sobel (1982). However, it appears to be inherent to fake news that their creation is costly. Among other kinds of costs a larger amount of fake news might lead to a higher probability of prosecution, and higher wage costs for bloggers.

news may increase the probability of legal prosecution and potential compensation payments. Moreover, we assume that c'' is bounded from below and above with $c'' \in [\underline{c}, \bar{c}]$. To avoid technical problems, we assume that f_i has a finite upper bound. All random variables are assumed to be statistically independent.

After having observed s_i, at the end of stage one the audience updates its prior beliefs about the distribution of qualities. From DeGroot (1970) we know that Bayesian updating conditional on s_i leads to a posterior distribution $q_{i1} \sim N\left(\bar{q}_{i1}, \sigma_{i1}^2\right)$ with $\bar{q}_{i1} = \bar{q}_{i0} + \Sigma_i \cdot (s_i - \beta \hat{f}_i - \bar{q}_{i0})$ and $\sigma_{i1}^2 = \Sigma_i \cdot \beta^2 \sigma_\varphi^2$, where

$$\Sigma_i := \frac{\sigma_{i0}^2}{\beta^2 \sigma_\varphi^2 + \sigma_{i0}^2} \tag{2}$$

describes the prior variance of quality q_i relative to the variance of the quality signal s_i. The variable $\hat{f}_i$ denotes the audience's belief about player i's fake news intensity.[6] Hence, the audience's posterior mean of player i's perceived quality will be larger than the prior mean if and only if the realized quality signal exceeds its expected value (i.e., $s_i > \beta \hat{f}_i + \bar{q}_{i0}$).

At stage two, players A and B enter a competition game. We aim at considering fake news intensities across different payoff structures. Therefore, at this point, we impose only mild assumptions on the payoffs at this stage and specify the exact utilities in Sections 4 and 5 below. However, to derive some general results, which will be true for all considered payoff structures, we assume that

(i) the strong player, say i with posterior lead $\bar{q}_{i1} - \bar{q}_{j1} \geq 0$, obtains a higher payoff at the second stage, $u_H(\cdot)$, while the weaker player gets $u_L(\cdot)$,

(ii) both payoffs depend on the difference between $\bar{q}_{i1}$ and $\bar{q}_{j1}$ such that we can write $u_H(\bar{q}_{i1} - \bar{q}_{j1})$ and $u_L(\bar{q}_{i1} - \bar{q}_{j1})$ with $u_L(\bar{q}_{i1} - \bar{q}_{j1}) < u_H(\bar{q}_{i1} - \bar{q}_{j1})$.

Below, we further specify the two functions u_H and u_L, and consider specific applications for the competition game at stage two (e.g., price competition between two firms, electoral competition, or promotion tournaments) that endogenously lead to $u_H(\bar{q}_{i1} - \bar{q}_{j1})$ and $u_L(\bar{q}_{i1} - \bar{q}_{j1})$.

The timing of the game is the following. At the beginning of stage one, the two players simultaneously choose their fake news intensities f_A and f_B, leading to publicly observable signals s_A and s_B, respectively. At the end of this stage, the audience updates its beliefs. At

[6]Note that we assume the audience to hold a point belief. As we will study pure strategy equilibria below, this assumption will necessarily hold in equilibrium.

the beginning of stage two, the players enter a competition game that determines their final payoffs.

As a solution concept we apply pure strategy perfect Bayesian equilibrium. Thus, an equilibrium of the game consists of a pure strategy profile incorporating the strategies of both players and the audience and a belief system such that the following three statements hold. First, both players play mutually best responses, anticipating the audience's behavior. Second, on the equilibrium path the audience derives its quality perceptions from players' fake news choices. Third, the individuals constituting the audience make choices that maximize their utility.

Our model also entails games in which players take a second action at the second stage, e.g., exerting effort in the competition or choosing prices. If this is the case, we follow the existing literature and impose a restriction on the set of perfect Bayesian equilibria to avoid equilibrium multiplicity: we study equilibria with passive beliefs, i.e., the audience's off equilibrium-path beliefs about the players' qualities do not depend on the observed behavior of the players at stage two.[7]

3. Creating Fake News

This section derives players' equilibrium fake news intensities. For this purpose, consider the optimization problem of player $i \in \{A, B\}$, who chooses f_i to maximize[8]

$$\begin{aligned} &E[u_H(\bar{q}_{i1} - \bar{q}_{j1})|\bar{q}_{i1} > \bar{q}_{j1}] \cdot P\left(\bar{q}_{i1} > \bar{q}_{j1}\right) \\ &\qquad + E[u_L(\bar{q}_{j1} - \bar{q}_{i1})|\bar{q}_{i1} < \bar{q}_{j1}] \cdot P\left(\bar{q}_{i1} < \bar{q}_{j1}\right) - c(f_i)\,, \end{aligned} \tag{3}$$

where $P\left(\bar{q}_{i1} > \bar{q}_{j1}\right)$ denotes the probability that i will be the strong player at stage two and E the expectation operator with respect to q_A, q_B, φ_A and φ_B.

As explained above, the key variable determining stage-two payoffs and, hence, incentives to create fake news is the posterior lead of the strong player. This lead is composed of stochastic and deterministic variables. For an easier comprehension of the problem, we separate out the stochastic elements of the posterior lead such that $\bar{q}_{i1} - \bar{q}_{j1} = \delta_i - \Psi_i -$

[7]The assumption of passive beliefs is very common in the related literature. Papers with a similar focus as ours either assume "passive" beliefs explicitly (Shelegia, 2011; Grunewald and Kräkel, 2017) or implicitly (Judd and Riordan, 1994; Bar-Isaac *et al.*, 2010; Bar-Isaac and Deb, 2014).

[8]Recall that the payoff functions u_H and u_L have been defined based on the posterior lead of the strong player, and in the second line j is the strong player.

$\beta\Sigma_j(f_j - \hat{f}_j) + \beta\Sigma_i(f_i - \hat{f}_i)$, with δ_i being stochastic and Ψ_i embracing the exogenous deterministic elements:

$$\delta_i := \Sigma_i \cdot (q_i + \beta\varphi_i) - \Sigma_j \cdot (q_j + \beta\varphi_j) \qquad \Psi_i := (1 - \Sigma_j)\,\bar{q}_{j0} - (1 - \Sigma_i)\,\bar{q}_{i0}. \quad (4)$$

Since any convolution of two normal densities again yields a normal density (e.g., Ross, 2010, pp. 35, 67–68), the composed random variable δ_i is normally distributed: $\delta_i \sim N\left(\mu_{\delta_i}, \sigma^2_{\delta_i}\right)$ with

$$\mu_{\delta_i} := \Sigma_i \bar{q}_{i0} - \Sigma_j \bar{q}_{j0} \quad (5)$$

$$\text{and} \quad \sigma^2_{\delta_i} := \Sigma_i^2 \sigma^2_{i0} + \Sigma_j^2 \sigma^2_{j0} + (\Sigma_i^2 + \Sigma_j^2)\beta^2\sigma^2_{\varphi} = \Sigma_i \sigma^2_{i0} + \Sigma_j \sigma^2_{j0}. \quad (6)$$

Let g_i denote the density of δ_i, and G_i the corresponding cumulative distribution function. Consequently, player i's objective function (3) can be rewritten as

$$\int_{\Psi_i + \beta\Sigma_j(f_j - \hat{f}_j) - \beta\Sigma_i(f_i - \hat{f}_i)}^{\infty} u_H\left(\delta_i - \Psi_i - \beta\Sigma_j(f_j - \hat{f}_j) + \beta\Sigma_i(f_i - \hat{f}_i)\right) g_i(\delta_i)\, d\delta_i$$
$$+ \int_{-\infty}^{\Psi_i + \beta\Sigma_j(f_j - \hat{f}_j) - \beta\Sigma_i(f_i - \hat{f}_i)} u_L\left(\Psi_i + \beta\Sigma_j(f_j - \hat{f}_j) - \beta\Sigma_i(f_i - \hat{f}_i) - \delta_i\right) g_i(\delta_i)\, d\delta_i - c(f_i)\,.$$

In general, the optimal amount of fake news can be interior $f_i^* > 0$ as well as a corner solution $f_i^* = 0$. In any interior equilibrium in pure strategies f_i^* $(i = A, B)$ is described by the player's first-order condition. Applying Leibniz's formula and using the fact that the audience derives its quality beliefs from the players' actual fake news intensities ($\hat{f}_i = f_i^*$ $(i = A, B)$) in any equilibrium, we obtain the following result.

Proposition 1. *In any interior equilibrium in pure strategies, player i's optimal fake news intensity, f_i^*, is described by*

$$\beta\Sigma_i \Bigg[\left(u_H(0) - u_L(0)\right) g_i(\Psi_i) + \int_{\Psi_i}^{\infty} u'_H(\delta_i - \Psi_i)\, g_i(\delta_i)\, d\delta_i \quad (7)$$
$$- \int_{-\infty}^{\Psi_i} u'_L(\Psi_i - \delta_i) g_i(\delta_i)\, d\delta_i \Bigg] = c'(f_i^*)\,.$$

Proposition 1 provides two insights with respect to the amount of fake news under different payoff structures and different institutional configurations. First, the payoff structure determines the marginal payoffs $u'_H(\cdot)$ and $u'_L(\cdot)$, which will shape players' incentives to create fake news (see (7)). In particular, optimal fake news intensities will crucially depend on whether players face a constant payoff structure so that $u'_H(\cdot) = u'_L(\cdot) = 0$, or whether the margin of victory is payoff relevant with $u'_H(\cdot), u'_L(\cdot) \neq 0$. The following sections will derive the resulting patterns in fake news for both cases and show which payoff structure leads to more fake news.

Second, Proposition 1 shows that the overall effect of more rigorous institutions on fake news intensities is composed of two sub-effects. To distinguish between them, let the term in square brackets in (7), which reflects the competition at stage two, be denoted by $\mathcal{C}_i$. Then, the effect of institutions on fake news intensities can be partitioned in the following way:

$$\underbrace{\frac{\partial\, \beta\Sigma_i}{\partial\beta}\cdot\mathcal{C}_i}_{\text{information effect}} + \underbrace{\beta\Sigma_i\cdot\frac{\partial\,\mathcal{C}_i}{\partial\beta}}_{\text{competition effect}} . \tag{8}$$

The *information effect* describes how a change in the institutional setup affects players' fake news intensities holding the influence of the competition at the second stage fixed. It arises because institutions shape how strongly the audience reacts to newly arriving information. Therefore, it is reflected by the impact of β on $\beta\Sigma_i$, where Σ_i denotes the weight by which the audience updates its prior beliefs when observing the quality signal. In contrast, the *competition effect* describes how a change in the institutional setup affects fake news intensities through its anticipated impact on the competition at stage two.

As (7) shows, $\mathcal{C}_i$ is positive in each interior equilibrium of the game, irrespective of the structure of the competition game at the second stage. Hence, the direction of the information effect is independent of the competition at stage two. In particular, the effect of β on $\beta\Sigma_i$ is given by

$$\frac{\partial}{\partial\beta}\beta\Sigma_i \quad = \quad \frac{\partial}{\partial\beta}\frac{\beta\sigma_{i0}^2}{\beta^2\sigma_\varphi^2+\sigma_{i0}^2} \quad = \quad \Sigma_i\frac{\sigma_{i0}^2-\beta^2\sigma_\varphi^2}{\beta^2\sigma_\varphi^2+\sigma_{i0}^2}, \tag{9}$$

On the one hand, the numerator of $\beta\Sigma_i$ increases with β. The more rigorous institutions – i.e., the smaller β – the fewer fake news will be observed by the audience and, hence, the less effective will be fake news, which reduces the players' incentives to create them. On the other hand, the denominator of $\beta\Sigma_i$ also increases with β. The smaller β the more fake news will be filtered out. As a consequence, the audience will rely more heavily on the news it receives – i.e., the weight for Bayesian updating, Σ_i, becomes larger – and the creation of fake news becomes more appealing to players A and B. The information effect of more rigorous institutions will, thus, increase players' inclination to create fake news if most of the variance of the signals s_i stems from exogenous fake news and not from quality uncertainty such that σ_{i0}^2 is smaller than $\beta^2\sigma_\varphi^2$. In this case the signal that the audience observes is not informative and will be almost disregarded. Hence, fake news intensities will be low. In such a situation, more rigorous institutions restore the signal's credibility, which may lead to a higher fake news intensity.

While the information effect of more rigorous institutions will be a recurrent theme under different payoff structures, changes in the institutional setup also give rise to the competition effect (cf. (8)). The nature of this effect clearly differs across payoff structures. The next sections consider under what circumstances more rigorous institutions are capable of reducing fake news intensities for two prominent classes of payoff structures.

4. Competition with a Constant Payoff Structure

As a first class of payoff functions, suppose that u_H and u_L are exogenously given constants with $u_H = \bar{u}_H > \bar{u}_L = u_L$. This approach captures situations in which there is no further action at the second stage and the player with a posterior lead receives a winner prize that does not depend on the magnitude of this lead. It, thereby, resembles electoral systems in which the politician with the better reputation wins the election (see application 4.2.1), the competition of firms in a market that is populated by price-insensitive consumers (see application 4.2.2), and promotion tournaments with wages being attached to jobs (see application 4.2.3).

For the case of constant payoffs, Proposition 1 yields the following result:

Corollary 1. *Suppose that $u_H = \bar{u}_H$ and $u_L = \bar{u}_L$ with $\bar{u}_H > \bar{u}_L$, and let*

$$-\beta^2 \Sigma_i^2 \left(\bar{u}_H - \bar{u}_L\right) g_i'\left(\Sigma_i \bar{q}_{i0} - \Sigma_j \bar{q}_{j0} - \sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}\right) < \underline{c} \tag{10}$$

be satisfied. Then, in equilibrium, player i's fake news intensity f_i^* ($i = A, B$) is described by

$$\beta \Sigma_i (u_H - u_L) g_i(\Psi_i) = c'(f_i^*) \tag{11}$$

Condition (10) guarantees existence of a pure-strategy equilibrium.[9] Similar to the tournament model of Lazear and Rosen (1981), existence requires that the density has to be sufficiently flat and the cost function sufficiently steep. According to Corollary 1, equilibrium intensity f_i^* equates marginal expected returns from winning the competition and marginal costs. As a consequence, the dissemination of fake news increases with a larger payoff spread $\bar{u}_H - \bar{u}_L$.

4.1. The Effect of Institutions

Having established the equilibrium, our setup allows to study how more rigorous institutions affect fake news intensities. The specific payoff structure yields clear cut results on the shape

[9]Note that g_i' attains its maximum in the left inflection point at $\Sigma_i \bar{q}_{i0} - \Sigma_j \bar{q}_{j0} - \sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}$.

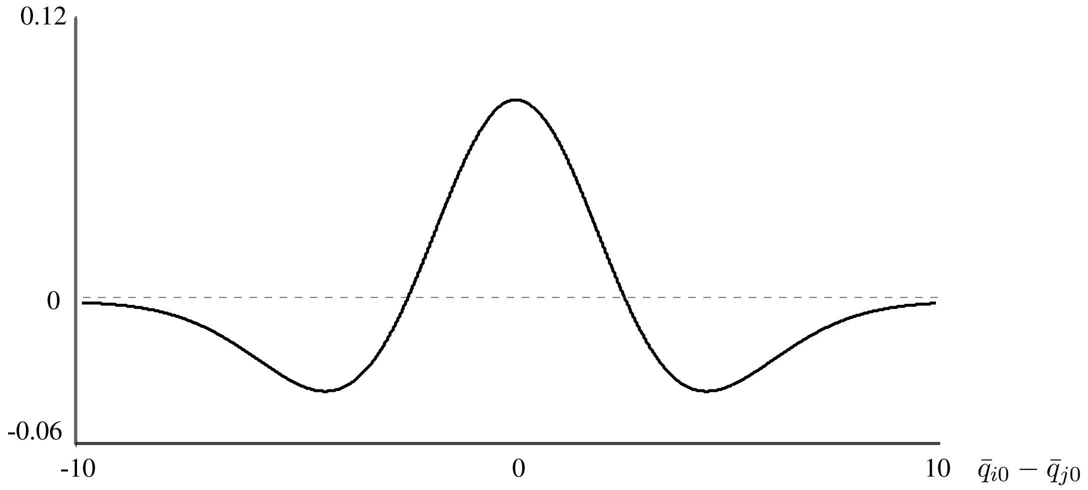

Figure 1: *The competition effect in dependence of $\bar{q}_{i0} - \bar{q}_{j0}$ for a constant payoff structure for $\sigma_{i0}^2 = \sigma_{j0}^2 = \sigma_{\varphi}^2 = 4$, $\beta = 0.5$, $\bar{u}_H = 6$, and $\bar{u}_L = 2$.*

of the competition effect and therefore on the overall impact of the institutional setup on the players' inclination to produce fake news.

Proposition 2. *If $u_H = \bar{u}_H$ and $u_L = \bar{u}_L$ with $\bar{u}_H > \bar{u}_L$, then the competition effect has the same sign for both players. There exists a threshold $\chi_i^{const} \geq 0$ such that the optimal fake news intensity f_i^* will increase with more rigorous institutions if and only if $|\bar{q}_{i0} - \bar{q}_{j0}| > \chi_i^{const}$, i.e., players are sufficiently heterogeneous in terms of prior expected qualities.*

As described in Section 3, the information effect of institutions will be positive if and only if $\sigma_{i0}^2 > \beta^2\sigma_{\varphi}^2$. However, as Proposition 2 shows, under a constant payoff structure more rigorous institutions will lead to *higher* fake news intensities of both players if their prior expected qualities are sufficiently different, irrespective of the sign of the information effect.

To understand this finding, consider Figure 1, which depicts the competition effect for different levels of players' initial heterogeneity $\bar{q}_{i0} - \bar{q}_{j0}$. It illustrates that the competition effect will be negative for both players if and only if players' heterogeneity is large. The intuition is as follows. If one of the players has a substantial prior lead, the winner of the competition is almost predetermined. Consequently, both players' incentives to create fake news are low. If in this situation β becomes small, however, the variance of the composed random variable δ_i will increase.[10] From the perspective of the players, the outcome of the competition will thus become less predictable. Therefore, the trailing player will have a real chance to win the competition, which restores both players' incentives to create fake news.[11]

[10]See the definition of $\sigma_{\delta_i}^2$ in (6).

[11]This interplay of heterogeneity and chance is similar to the influence of luck in tournaments with heterogeneous contestants; see Kräkel (2008) and Imhof and Kräkel (2016).

As a consequence, given a sufficiently large degree of initial heterogeneity, the competition effect of more rigorous institutions will induce both players to choose higher fake news intensities in equilibrium.

At a cursory first glance, it seems counterintuitive that more rigorous institutions lead to an increase of the variance of δ which is crucial for the shape of the competition effect. On the one hand, a reduction in β indeed reduces the impact of exogenous fake news φ_i, as can be seen from (1). As we have seen in Section 3, however, a reduction of β also induces the audience to rely more heavily on the received quality signals. In other words, the audience assigns larger weights to the random variables φ_A, φ_B, q_A, and q_B when updating beliefs, which boosts the impact of chance. Expression (6) shows that the latter effect dominates the former.

Importantly, Proposition 2 shows that the competition effect will dominate the information effect if heterogeneity becomes strong. This holds true even in the limit of very strong heterogeneity because the information effect converges to zero at a faster rate than the competition effect. Therefore, the shape of the overall effect of more thorough institutions resembles the shape of the competition effect: More rigorous institutions induce higher fake news intensities by both players if and only if players are sufficiently heterogeneous.

4.2. Applications

In this section we illustrate several settings at the second stage leading to constant payoff functions. The goal of this section is not to provide a comprehensive overview but to show how our results can generate interesting insights in a large variety of applications.

4.2.1. Political Competition and Lobbying

Similar to some models on political selection, assume that two candidates run for office in an election where the outcome only depends on their reputation (as for example in Majumdar and Mukand, 2004; Callander, 2008). Both candidates $i \in \{A, B\}$ with uncertain abilities q_i can try to influence the media via fake news at the first stage to obtain a good reputation, and compete at the second stage for votes. The candidate that obtains more votes wins the election and receives winner prize $\bar{u}_H$ and the loser receives $\bar{u}_L$. The electorate is heterogeneous in its tastes such that voter θ votes for candidate A if and only if $\bar{q}_{A1} > \bar{q}_{B1} + \theta$, where θ is distributed according to cdf $F(\cdot)$ which is symmetric around 0. As a consequence, the vote share of candidate i is larger than the one of candidate j if and only if $\bar{q}_{i1} > \bar{q}_{j1}$. Hence, this setup directly translates into the one above. Proposition 2 then predicts that more rigorous institutions will lead to higher fake news intensities if and only if the candidates sufficiently differ in their initial chance to win the election.

The setting can also be interpreted as a model of two lobbyists that aim to convince a decision maker to implement their project. The lobbyist whose proposal is implemented receives utility $\bar{u}_H$, whereas the less successful lobbyist only receives $\bar{u}_L$. At stage one, lobbyist i creates fake news to manipulate the decision maker's quality belief about his project which is of quality q_i. At stage two, the decision maker chooses the project which he beliefs has higher expected quality.

4.2.2. Price Competition

Suppose the two players A and B are two firms that compete via deceptive advertising (e.g, Zinman and Zitzewitz, 2016) or online review manipulation (e.g, Dellarocas, 2003, 2006; Mayzlin, 2006; Mayzlin *et al.*, 2014) at stage one to exaggerate the usefulness of their goods, and via prices at stage two. The audience is given by the consumers who purchase a good from one of the two firms. Firm i ($i = A, B$) offers a complex experience good[12] i (e.g., a car, a computer, or a mobile phone) whose quality $q_i \sim N\left(\bar{q}_{i0}, \sigma_{i0}^2\right)$ is uncertain for the two firms and the consumers.[13]

At stage two, firms decide on prices. If the market is characterized by zero price elasticity, consumers ignore product prices and purchase on the basis of posterior expected quality only. For example, we can think of a market for very expensive luxury goods. In this case, the two firms A and B set prices equal to the consumers' maximum willingness to pay, and all consumers purchase the good with the higher expected quality $\bar{q}_{i1} = \max\{\bar{q}_{A1}, \bar{q}_{B1}\}$. Whereas the quality leader i serves the whole market and receives profits $\bar{u}_H > 0$, firm $j \neq i$ with the lower expected quality earns profits $\bar{u}_L = 0$.

Proposition 2 shows how more rigorous institutions affect firms' optimal fake news intensities in such a market. In particular, they will lead to higher fake news intensities if and only if the initial degree of vertical product differentiation $\bar{q}_{i0} - \bar{q}_{j0}$ is sufficiently large.

[12]The notion of an experience good has been introduced in the economic literature by Nelson (1970, 1974). Consumers learn the quality of an experience good only after its purchase when using the good.

[13]This two-sided quality uncertainty stems from the fact that the consumption quality of a specific good crucially depends on its technical features, whose usefulness is uncertain for consumers, and on the consumers' preferences, which are uncertain to the firms (see, e.g, Caminal and Vives, 1996; Bar-Isaac and Deb, 2014; Drugov and Troya-Martinez, 2015).

4.2.3. *Influence Activities and Job Promotion*

Following the papers by Milgrom (1988) and Milgrom and Roberts (1988), in some situations politicking by workers might be important to get promoted to a better job in the hierarchy. Suppose that two workers A and B try to influence their superior that is in charge of the promotion decision by creating fake news within the workforce, among the customers and among the suppliers with the purpose to appear more suitable for the vacant position.[14] If worker i has attained a better reputation in terms of a larger expected talent than co-worker j, i.e., $\bar{q}_{i1} > \bar{q}_{j1}$, the former one will be promoted and earn the high income $\bar{u}_H$, whereas his opponent will stay at his current job and receive the lower income $\bar{u}_L$. According to Proposition 2, in a sufficiently unbalanced job-promotion tournament more rigorous institutions will induce higher fake news intensities.

5. Competition with an Affine Payoff Structure

The previous section has analyzed fake news intensities and how they are affected by the institutional setup if players face a constant payoff structure and do not have additional actions available at the second stage. However, in many environments players interact at a second stage after they have created fake news at the first stage: e.g., politicians can spend additional resources for campaigning or have to find compromises in parliament (see application 5.2.1), and firms compete in prices to sell their products (see application 5.2.2). Typically, these interactions yield payoffs that depend on the magnitude of the posterior lead, $\bar{q}_{i1} - \bar{q}_{j1} > 0$. Even without further interaction at stage two, players' payoffs often depend on the magnitude of the posterior lead, e.g., promoted workers care about their relative reputation as it determines their future careers (see application 5.2.3). This section explores how our previous results change in such cases.

For this purpose, let u_H and u_L be affine such that the strong player i with posterior lead $\bar{q}_{i1} - \bar{q}_{j1} > 0$ receives the high stage-two payoff

$$u_H(\bar{q}_{i1} - \bar{q}_{j1}) := \bar{\eta} + \eta_H \cdot (\bar{q}_{i1} - \bar{q}_{j1}), \tag{12}$$

whereas the weak player j gets the low stage-two payoff

$$u_L(\bar{q}_{i1} - \bar{q}_{j1}) := \bar{\eta} + \eta_L \cdot (\bar{q}_{i1} - \bar{q}_{j1}), \tag{13}$$

[14] Alternatively, workers might directly communicate with the superior and act as yes men (e.g., Prendergast (1993), Ewerhart and Schmitz (2000) or try to appear as an expert (Ottaviani and Sørensen, 2006).

where $\eta_H \geq |\eta_L|$ and $\eta_H > 0$. While we assume this linear structure of payoffs for simplicity, the applications below clarify that exactly this structure arises endogenously in many well-known environments. The relation $\eta_H \geq |\eta_L|$ implies that the strong player is, at least weakly, better off than the weak player.[15] To capture a large variety of different environments, we allow η_L to be positive as well as negative. If $\eta_L > 0$, it still holds that each player aims to be the quality leader at stage two. However, the player that is in the weaker position prefers to be of low expected quality. Such situations typically arise if two firms compete in prices. Then both firms may strictly benefit from vertical product differentiation, i.e., from products that maximally differ in quality, to alleviate price competition (see, e.g., Shaked and Sutton, 1982). If, in contrast, $\eta_L < 0$, each player prefers to have a high expected quality at stage two irrespective of his quality ranking. Such a situation is typical of a contest where each player benefits from being strong, because strength implies low effort costs or a high productivity (see, e.g., Konrad, 2009). Combining (12) and (13) with Proposition 1 yields the following corollary:

Corollary 2. *Suppose u_H and u_L are affine and described by (12) and (13). There will exist a unique pure-strategy equilibrium (f_A^*, f_B^*) if for both players*

$$\beta^2 \Sigma_i^2 \left(\eta_H + \eta_L\right) g_i(\mu_{\delta_i}) < \underline{c}. \tag{14}$$

The equilibrium is characterized by a corner solution $f_i^* = 0$ if and only if $(\eta_H + \eta_L)\, G_i(\Psi_i) \geq \eta_H$. Otherwise, players choose fake news intensities $f_i^* > 0$ being described by

$$\beta \Sigma_i \left[\eta_H - (\eta_H + \eta_L)\, G_i(\Psi_i)\right] = c'(f_i^*) \tag{15}$$

with $i, j = A, B$ and $i \neq j$.

Corollary 2 shows how an affine payoff structure at the second stage affects players' incentives to create fake news. Player i's probability of becoming the strong competitor at the second stage, $1 - G_i(\Psi_i) = P(\bar{q}_{i1} > \bar{q}_{j1})$, determines how his payoff is influenced by the magnitude of the posterior lead, which then determines i's optimal fake news intensity. If this probability is sufficiently low (i.e., $G_i(\Psi_i)$ is large), his expected marginal incentives to achieve a better reputation at stage two are close to $-\eta_L$. Therefore, he faces only weak incentives to create fake news. He will even prefer to create no fake news at all, if $\eta_L > 0$. In this situation, given that i indeed becomes the weak player with $\bar{q}_{i1} < \bar{q}_{j1}$, a zero fake

[15] If $\eta_H < |\eta_L|$ with $\eta_L < 0$, each player will prefer being the weak competitor to being the strong one, given the same absolute value of $|\bar{q}_{i1} - \bar{q}_{j1}|$.

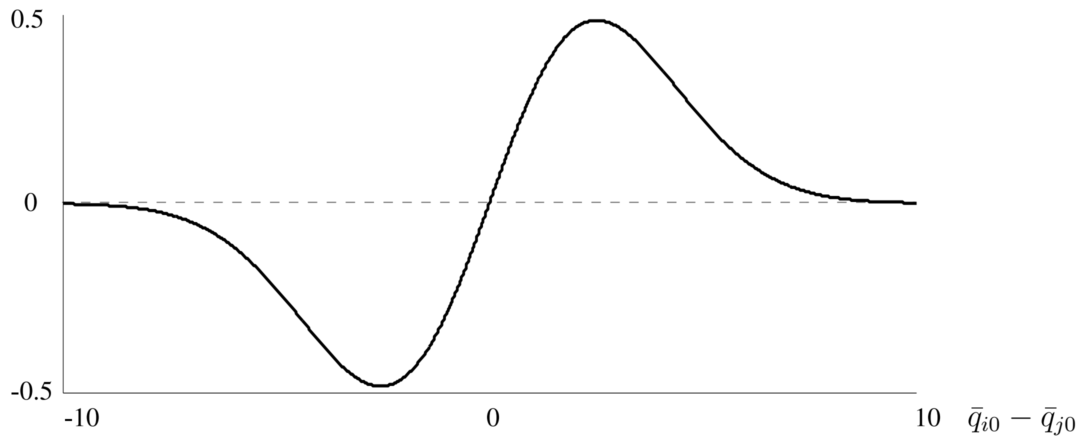

Figure 2: *The competition effect in dependence of $\bar{q}_{i0} - \bar{q}_{j0}$ for affine functions for $\sigma^2_{i0} = \sigma^2_{j0} = \sigma^2_{\varphi} = 4$, $\beta = 0.5$, $\eta_H = 6$, and $\eta_L = 2$.*

news intensity does not only minimize costs at stage one but also maximizes expected payoffs from the competition at stage two as also the weak player strictly benefits from strong heterogeneity.

Finally, the larger η_H and the smaller η_L the higher will be the relative returns from creating fake news, which increases f_i^*. In particular, player i's fake news intensity will be large if η_L is negative instead of positive. As Section 5.2 will show, the sign of η_L reflects different applications within the class of affine payoff structures, e.g., price competition and political competition. We can therefore, use this insight to generate predictions in which of these applications to expect larger amounts of fake news.[16]

5.1. The Effect of Institutions

Next, we turn to the question how institutions affect fake news intensities. Equation (15) shows that β affects f_i^* in two ways. First, as indicated by the term $\beta\Sigma_i$ in front of the expression in square brackets, there is the same information effect as described in Sections 3 and 4. The crucial difference to the constant payoff structure is the shape of the competition effect, which is depicted in Figure 2. Under constant payoffs, the competition effect stems from a change in the players' marginal probability of winning the competition, g, which leads to the same impact of β on both players' fake news intensities in equilibrium. Under affine payoffs, however, the competition effect stems from a change in the players' probabil-

[16]Under somewhat more restrictive assumptions, Corollary 2 also allows to compare fake news intensities of the prior leader and the player that is in an inferior position at the beginning of stage one. In particular, $\bar{q}_{i0} > \bar{q}_{j0}$ implies $f_i > f_j$ if $\Sigma_i = \Sigma_j$.

ity of becoming the competitor with a posterior lead at stage two. As player i's probability of becoming the competitor with a posterior lead will decrease if player j's respective probability increases and vice versa, β cannot have the same impact on both players' fake news intensities (see Figure 2).

Proposition 3. *Suppose u_H and u_L are affine and given by (12) and (13) with $\eta_H > |\eta_L|$. Then, the competition effect is positive for player i if and only if $\bar{q}_{i0} > \bar{q}_{j0}$. Let $\sigma_{i0}^2 > \beta^2\sigma_\varphi^2$, then there exists a threshold $\chi_i^{affine} < 0$ such that player i will (weakly) increase his fake news intensity as a response to more rigorous institutions if and only if $\bar{q}_{i0} - \bar{q}_{j0} < \chi_i^{affine}$.*

The intuition for the results in Proposition 3 is the following. Suppose player i enters the game with the prior lead $\bar{q}_{i0} - \bar{q}_{j0} > 0$. If in this situation institutions against fake news become more rigorous (i.e., β decreases), the signals s_A and s_B will appear more trustworthy to the audience. Hence, by creating fake news, it will become easier for the trailing player j to catch up with i and to end up as the competitor with a posterior lead at stage two. As player j's posterior expected quality is particularly important to him if he becomes the quality leader ($\eta_H > |\eta_L|$), his incentives to create fake news at stage one become stronger. In contrast, more rigorous institutions deteriorate i's favorable starting position. His probability of becoming the competitor with a posterior lead decreases, which reduces his incentives to create fake news.

As we know from Section 3, the sign of the information effect is ambiguous. To obtain a clear-cut result, in the second part of Proposition 3 we assume that $\sigma_{i0}^2 > \beta^2\sigma_\varphi^2$ for $i \in \{A, B\}$ so that the information effect is positive for both players. Thus, if player i starts with the prior lead $\bar{q}_{i0} - \bar{q}_{j0} > 0$, both the information effect and the competition effect will be positive for him. Consequently, more rigorous institutions unambiguously decrease his incentives to create fake news. If, however, player i starts as the trailing one with $\bar{q}_{i0} - \bar{q}_{j0} < 0$, the information effect and the competition effect will work into opposite directions. In that case, his incentives to create fake news will increase with more rigorous institutions if his handicap suffices for the competition effect to dominate the information effect.

The previous findings for the interior equilibrium directly reveal the impact of more rigorous institutions on the corner solution. As we know from the proof of Proposition 3, $\partial G_i/\partial\beta$ will be negative if and only if player i enters the game with a prior lead, or in other words:

Corollary 3. *If $\bar{q}_{i0} < \bar{q}_{j0}$ holds (does not hold), more rigorous institutions will make the condition for a corner solution $f_i^* = 0$ more difficult (easier) to be satisfied.*

The intuition for the result of Corollary 3 is similar to that for the competition effect. If player i starts as trailing competitor, he will benefit from more rigorous institutions, working against j's prior lead. Consequently, player i has stronger incentives to choose a positive fake news intensity. If, however, player i starts with a prior lead, more rigorous institutions will make it more difficult for him to keep his position such that he has fewer incentives to become active by creating fake news at stage one.

5.2. Applications

We now consider applications in which affine payoff functions arise from the competition game at stage two.

5.2.1. Political Competition and Lobbying

An example for the case of affine payoff functions (12) and (13) is given by a prominent class of competition games at stage two that traces back to Tullock (1980). Suppose player i (i.e., politician i or lobbyist i) is the strong competitor at stage two with posterior lead $\bar{q}_{i1} - \bar{q}_{j1} > 0$. This lead makes it easier for i to acquire capital for campaigning so that the lead translates into additional money that can be invested as resources during the campaign. Let these additional funds be $\gamma \cdot (\bar{q}_{i1} - \bar{q}_{j1})$ with $\gamma > 0$,[17] and the benefit from winning the competition be B. Appendix B shows that equilibrium payoffs in the corresponding Tullock contest are given by[18]

$$\pi_i^* = \frac{B}{4} + \gamma \cdot (\bar{q}_{i1} - \bar{q}_{j1}) \quad \text{and} \quad \pi_j^* = \frac{B}{4}. \tag{16}$$

As we can see from (16), $\eta_L = 0$ so that the players' interests are not aligned at the competition stage and the weak player does not benefit from a large degree of heterogeneity.

As an alternative microfoundation for an affine payoff structure consider an electoral competition with subsequent policy choice. In contrast to the case of a constant payoff structure, affine payoff structures allow for the utility of winning an election to depend on the margin of victory. This is typical of parliamentary elections in consensus democracies like Switzerland the Netherlands, and Belgium where also the election loser retains some say in the political

[17] Instead of additional external funding, $\gamma \cdot (\bar{q}_{i1} - \bar{q}_{j1})$ could be interpreted as a lead in reputation by which player i enters stage two, and that player j has to invest more into campaigning to catch up with i.

[18] See also Loury (1979), Baye and Hoppe (2003), and Konrad (2009). Similar payoffs can be obtained if the election winner is determined by an all-pay auction and the benefit of the election winner depends on his posterior expected quality; see Section C.1 in the Online Appendix.

process. To depict an idealized representation of these electoral institutions it is common in the literature of political compromise to assume that the implemented policy depends on the exact voting outcome of all parties (see for example Fishburn and Gehrlein, 1977; Grossman and Helpman, 1996; Grunewald *et al.*, 2017). To keep this application simple, assume that $\bar{q}_{i1} - \bar{q}_{j1} > 0$ is the number of votes by which party i outperformed party j in the election. After the election, a policy x has to be implemented and party i's utility is given by x, while party j's utility is given by $-x$. Parties have to make a compromise in parliament. In this process, party i can shift the location of the policy upward or downward by the number of votes that he won in the election times η_H. Hence, the implemented policy becomes $x = \eta_H \cdot (\bar{q}_{i1} - \bar{q}_{j1})$.

5.2.2. Price Competition

Let the two players A and B be two firms that offer experience goods with uncertain qualities q_A and q_B. However, contrary to Section 4.2.2, stage two is now described by a simplified version of the price-competition game considered by Shaked and Sutton (1982).[19] For given posterior expected qualities, $\bar{q}_{A1}$ and $\bar{q}_{B1}$, firms A and B simultaneously decide on prices, p_A and p_B, to maximize profits. Thereafter, each consumer purchases either one unit of good A or one unit of good B. Production costs are normalized to zero and the mass of risk-neutral consumers is assumed to be one. Consumer types θ are uniformly distributed over $[\underline{\theta}, \bar{\theta}]$ with $0 \leq \underline{\theta} \leq \bar{\theta}/2$ and $\bar{\theta} = \underline{\theta} + 1$ such that the density is 1. Each consumer knows his type, but the two firms only know the distribution over θ. A consumer of type θ receives expected utility $\theta \cdot \bar{q}_{i1} - p_i$ from purchasing one unit of good i ($i = A, B$) at price p_i.

Suppose, w.l.o.g., that firm i becomes the quality leader, i.e., $\bar{q}_{i1} > \bar{q}_{j1}$. Then, in equilibrium, the second-stage profits of the two firms i and j ($i = A, B$; $i \neq j$) are given by

$$\pi_i^* = \bar{\Theta} \cdot (\bar{q}_{i1} - \bar{q}_{j1}) \quad \text{and} \quad \pi_j^* = \underline{\Theta} \cdot (\bar{q}_{i1} - \bar{q}_{j1}) \tag{17}$$

with $\bar{\Theta} := (\bar{\theta} + 1)^2/9 > (2 - \bar{\theta})^2/9 =: \underline{\Theta}$.[20] According to (17), both firms strictly benefit from vertical product differentiation, i.e., both firms' profits increase with the posterior lead $\bar{q}_{i1} - \bar{q}_{j1}$. The larger this lead, the less intense will be the price competition at stage two. Ex ante each firm prefers to have the higher posterior expected quality but if it is in the inferior

[19]The following set-up with vertical product differentiation can also be found in the marketing literature, see Mehta *et al.* (2003).

[20]See Section C.2 in the Online Appendix for the derivation of the equilibrium profits. See also Tirole (1988), 296–297, and Grunewald and Kräkel (2017).

position at stage two, ex post it will benefit from being as weak as possible. Consequently, the presumable quality leader chooses a high fake news intensity whereas the presumably trailing firm chooses a low fake news intensity, which will be even zero if the trailing firm is sufficiently weak.

Applying Proposition 3 to this setting of price competition allows us to investigate whether institutions that eliminate fake news in the media would be capable of reducing firms' engagement in creating fake news, e.g., their willingness to post fake reviews on the Internet. In particular, our result predicts that more rigorous institutions will foster the creation of fake news by a firm that is sufficiently weak when entering the game. In contrast, its predominant rival will be discouraged from investing in fake news.

5.2.3. Influence Activities and Job Promotion

Application 4.2.3 has implicitly assumed that workers are compensated via wages attached to jobs, like in internal labor markets of large corporations (e.g, Doeringer and Piore, 1971). In that case, outside workers enter a corporate hierarchy exclusively via specific ports of entry at the lowest level of the hierarchy and then get internally promoted according to acquired firm-specific human capital and realized performance. As the wages that are tied to the different hierarchy levels are increasing toward the top, promotion competition resembles a typical tournament with given prizes.

However, as Baker *et al.* (1994) and subsequent empirical studies have shown, there is large variation of pay within the same hierarchy level of real corporations, implying that the ideal construct of an internal labor market often does not exist in practice. Instead, real employers discriminate in wages between promoted workers and it seems reasonable that workers with higher expected talent receive higher wages, e.g., to prevent them from leaving the firm. Moreover, we can imagine that a promoted worker i also benefits from a larger posterior lead $\bar{q}_{i1} - \bar{q}_{j1} > 0$ because his promotion is more respected by his co-workers, which might be accompanied by less arguing and lower opportunity costs of time when enforcing (maybe unpopular) decisions at the new job. Such incentives seem particularly prevalent if the tournament winner i becomes the leader of his own team, which is aware of i's past performance. To sum up, in the affine payoff functions (12) and (13), we can interpret $\eta_H \cdot (\bar{q}_{i1} - \bar{q}_{j1})$ and $\eta_L \cdot (\bar{q}_{i1} - \bar{q}_{j1})$ with $\eta_L \leq 0$ as the utility of the promoted worker and the disutility of the not promoted worker based on higher and lower relative reputation, respectively.

6. IS FAKE NEWS INTENSITY HIGHER UNDER CONSTANT OR AFFINE PAYOFFS?

Whether the payoff structure is constant or affine in a given competition is often at the discretion of a superior organization – promoted workers can lead their former team or an unrelated team, elected politicians can be equipped with comprehensive power to change a policy or there might be multiple layers of checks and balances or other veto players in the political process. It is therefore an obvious question of interest, which of the two payoff structures leads to a higher intensity of fake news. Recall that players' cost functions do not depend on the payoff structure. To analyze how the amount of fake news differs across payoff structures in interior equilibria, it then suffices to compare the left-hand sides of (11) and (15). However, there may be corner equilibria in the case of affine payoff functions in which player i's fake news intensity is zero. Overall, fake news intensity of player i will, thus, be higher under affine than under constant payoffs if and only if $\Delta_i > 0$ with Δ_i being defined as

$$\Delta_i = \max\left\{0, \eta_H - (\eta_H + \eta_L)\, G_i(\Psi_i)\right\} - (\bar{u}_H - \bar{u}_L)\, g_i(\Psi_i)\,.$$

The following proposition summarizes under which conditions this will be the case.

Proposition 4. *Whether player i's fake news intensity is higher under a constant or an affine payoff structure depends on the players' initial heterogeneity. There exists a threshold $\bar{\eta}_L < 0$ such that the following three statements hold:*
(i) If $\eta_L > 0$, there exists a cutoff ξ such that Δ_i will be positive if and only if $\bar{q}_{i0} - \bar{q}_{j0} > \xi$.
(ii) If $\eta_L \in [\bar{\eta}_L, 0)$, there exists an interval $[\xi', \xi'']$ such that Δ_i will be positive if $\bar{q}_{i0} - \bar{q}_{j0} \notin [\xi', \xi'']$.
(iii) If

$$\eta_H > (\bar{u}_H - \bar{u}_L) g_i\left(\Sigma_i \bar{q}_{i0} - \Sigma_j \bar{q}_{j0}\right), \tag{18}$$

then $\bar{\eta}_L > -\eta_H$. In this case, Δ_i will be positive for all $\eta_L < \bar{\eta}_L$.

If $\eta_L > 0$, both players with affine payoffs benefit from a larger posterior lead. Such a situation is typical of price competition where both players benefit from larger vertical product differentiation due to less intense competition (see application 5.2.2). If the initial handicap of the trailing player is sufficiently large, he will choose not to create any fake news under affine payoffs. Under a constant payoff structure, however, fake news will always be created. Hence, players with a substantial handicap will create more fake news under a constant than under an affine payoff structure. In contrast, players with a substantial prior lead will create more fake news under an affine payoff structure. Intuitively, the more confident the player is to be the quality leader after the fake news stage, the more heavily he will invest in fake news under affine payoffs, as payoffs increase with the magnitude of the posterior lead. The opposite is true for players under a constant payoff structure: for players that are almost certain to win the competition there is no urge to create fake news.

Suppose next that $\eta_L \in [\bar{\eta}_L, 0)$. Given affine payoffs, both players then seek to achieve a high posterior expected quality no matter whether they will end up with a posterior lead or not (see for example applications 5.2.1 and 5.2.3). Therefore, fake news intensities will be strictly positive under affine payoffs even if initial player heterogeneity is large. Under constant payoffs, however, players' equilibrium fake news intensities approach zero if the initial degree of heterogeneity becomes large. As a consequence, fake news intensities are larger for affine payoffs if initial heterogeneity is sufficiently large. In contrast, players will create more fake news under constant payoffs in case of a tight competition.

Finally, suppose again that in case of affine payoffs the players' incentives are not aligned, as indicated by $\eta_L < 0$. If it is sufficiently important for the players to become the competitor with a posterior lead (i.e., η_H is large) and to avoid becoming the trailing competitor at stage two (i.e., $|\eta_L|$ is large), the players' fake news incentives for affine payoffs will be strong, independent of the initial degree of player heterogeneity. As a consequence, both players' fake news intensities are strictly larger compared to the situation with constant payoffs.

The findings above consider how fake news intensities of single players differ under the two payoff structures. As Proposition 4 shows, it might be the case that the fake news intensity of one player is higher under affine payoffs compared to the case of constant payoffs while the opposite holds true for his opponent. In such cases, the effect of the payoff structure on the overall amount of fake news by both players will also depend on the individual weights for Bayesian updating, Σ_i, and initial quality uncertainty as measured by σ_{i0}^2. However, the proposition implies clear-cut results for those cases in which both candidates' fake news intensities are affected in the same way by a change of the payoff structure. In particular, the sum of fake news intensities will be larger under an affine payoff structure if either $\eta_L < 0$ and $|\eta_L|$ and η_H are large, or if $\eta_L < 0$ is intermediate and initial player heterogeneity is large. In contrast, the sum of fake news intensities will be larger under a constant payoff structure if $\eta_L < 0$ is intermediate and players are rather homogeneous when entering the two-stage game.

Applications

In the next paragraphs, we utilize our applications to briefly provide some context for the results derived in Proposition 4. While the following arguments make specific assumptions about the exact structures of competition that we observe in reality, they can also inform future studies that set out to compare fake news intensities in so far neglected environments across different payoff structures. In particular, we derive a first set of testable empirical predictions, when to expect large amounts of fake news and when fake news intensities should be expected to be rather moderate.

Reconsider the applications from Sections 4 and 5. As application 5.2.2 shows, price competition with price-sensitive consumers may lead to an affine payoff structure in which $\eta_L > 0$ holds. Case (i) of Proposition 4 therefore allows to infer whether firms spread more fake news under price competition a la Shaked and Sutton (1982) or if they compete for price-insensitive consumers as in application 4.2.2, which illustrates a market for luxury goods. In particular, price sensitive consumers will cause larger amounts of fake news by a firm if and only if it owns a strong brand, i.e, ex ante consumers attach high quality beliefs to that firm's products.

Case (ii) of Proposition 4 analyzes a situation with affine payoffs where both players profit from a higher posterior quality belief irrespectively of whether they have won the competition or not. Such a situation is arguably plausible in lobbying contests or in promotion tournaments if players face repeated interactions after the fake news stage (see application 5.2.3). We compare such a situation to a contest in which there is no further interaction, e.g., because the promoted worker will manage a team in another division. There should be more fake news if the new manager interacts with his former team if and only if team members are rather heterogeneous in their ex ante ability. In contrast, promotions to another division induce more fake news if team members are rather similar ex ante.

Finally, case (iii) of Proposition 4 considers a situation with affine payoffs where both players substantially profit from a higher posterior quality belief. Such a situation seems plausible for parliamentary elections where an extra seat in parliament increases a party's influence on implemented policies independently of whether it has more or less seats than its opponents (see application 5.2.3). For example, the winning party now has a clear majority to implement its political plans, or the losing party now has the possibility to block certain decisions of the winning party. In such a situation, fake news intensities will necessarily be higher in campaigns for an election in which the margin of victory is relevant compared to elections that have a fixed-price structure as it is the case in presidential elections.

7. Conclusion

This paper provides a general framework for investigating the incentives to create fake news across different environments and institutional configurations. For this purpose, we consider a two-stage model in which two players may create fake news at stage one and enter a competition at stage two. We represent the environment in which players act by the anticipated payoff structure, and distinguish between a setting in which the player with the better reputation earns a fixed prize and a setting where payoffs depend on the magnitude of this player's lead. The simplicity of our setting enables us to generate insights that apply to many different environments in which fake news may occur, e.g., political competition, consumer goods markets, and lobbying. At the same time, however, we also abstract from various specifics of real world settings and institutions that may foster the intensity of fake news.

To study further determinants of the incentives to create fake news appears to be a promising route for future research. In our analysis, we abstract, for example, from motivated beliefs (Bénabou, 2015) on the side of the audience, and long-term image concerns on the side of the players. However, it is intuitively plausible that players' choices to create fake news depend on either of these. Due to its tractability, our framework lends itself to study the impact of such or related matters in various extensions.

Our setup also provides a first set of testable predictions in which environments and under which institutions to expect fake news. We hope that it therefore initiates a directed empirical evaluation of the observed patterns of fake news. Such analysis could assist policy makers as well as organizations that have discretion over the environments and payoff structures in which players act. From their perspective, a setting that induces less fake news may be preferable as fake news are often associated with bad choices by the audience that is targeted. Moreover, if people expect that fake news are widely used and have a large impact on real decisions, they might fundamentally question the political and the market system. An empirical analysis appears also appealing because various experimental evidence has shown that humans have an intrinsic preference for telling the truth, i.e., against creating fake news (see, Abeler *et al.*, 2016). Such a preference might interact with the institutional setup and the function in which a player spreads fake news. Hence, an empirical test would also help to judge whether our predictions are obscured by dimensions of the incentive structure that we do not model or whether monetary incentives to create fake news overturn any psychological motives for truth telling.

Appendix

A. Proofs of Propositions and Corollaries

Proof of Proposition 2. By transforming the normal distribution into the standard normal distribution with density ϕ, equation (11) can be rewritten as

$$\frac{\beta\Sigma_i(u_H-u_L)}{\sqrt{\Sigma_i\sigma_{i0}^2+\Sigma_j\sigma_{j0}^2}}\phi\left(\frac{\bar{q}_{j0}-\bar{q}_{i0}}{\sqrt{\Sigma_i\sigma_{i0}^2+\Sigma_j\sigma_{j0}^2}}\right)=c'(f_i^*)\,. \tag{A.1}$$

Computing the derivative of the left-hand side with respect to β yields

$$\frac{(u_H-u_L)\sigma_{i0}^2}{\left(\beta^2\sigma_\varphi^2+\sigma_{i0}^2\right)^2}\frac{\sigma_{i0}^2-\beta^2\sigma_\varphi^2}{\sqrt{\Sigma_i\sigma_{i0}^2+\Sigma_j\sigma_{j0}^2}}\phi\left(\frac{\bar{q}_{j0}-\bar{q}_{i0}}{\sqrt{\Sigma_i\sigma_{i0}^2+\Sigma_j\sigma_{j0}^2}}\right)$$
$$+\frac{(u_H-u_L)\beta\sigma_{i0}^2}{\beta^2\sigma_\varphi^2+\sigma_{i0}^2}\frac{\left(\Sigma_i^2+\Sigma_j^2\right)\beta\sigma_\varphi^2}{\left(\Sigma_i\sigma_{i0}^2+\Sigma_j\sigma_{j0}^2\right)^{\frac{3}{2}}}\times$$
$$\left[\phi\left(\frac{\bar{q}_{j0}-\bar{q}_{i0}}{\sqrt{\Sigma_i\sigma_{i0}^2+\Sigma_j\sigma_{j0}^2}}\right)+\frac{\bar{q}_{j0}-\bar{q}_{i0}}{\sqrt{\Sigma_i\sigma_{i0}^2+\Sigma_j\sigma_{j0}^2}}\phi'\left(\frac{\bar{q}_{j0}-\bar{q}_{i0}}{\sqrt{\Sigma_i\sigma_{i0}^2+\Sigma_j\sigma_{j0}^2}}\right)\right].$$

Using the fact that $\phi'(x)=-x\phi(x)$, the derivative will be positive iff

$$\frac{\sigma_{i0}^2-\beta^2\sigma_\varphi^2}{\beta^2\sigma_\varphi^2+\sigma_{i0}^2}+\frac{\beta^2\sigma_\varphi^2\left(\Sigma_i^2+\Sigma_j^2\right)}{\Sigma_i\sigma_{i0}^2+\Sigma_j\sigma_{j0}^2}\cdot\left[1-\frac{\left(\bar{q}_{j0}-\bar{q}_{i0}\right)^2}{\Sigma_i\sigma_{i0}^2+\Sigma_j\sigma_{j0}^2}\right]>0.$$

Whereas the first addend corresponds to the information effect of creating fake news (see (9)), the second addend describes the competition effect. As this expression is identical for both players, the competition effect has the same sign for A and B. Moreover, it is monotonically decreasing with the degree of initial player heterogeneity as measured by $|\bar{q}_{i0}-\bar{q}_{j0}|$. If its value becomes sufficiently large, the whole derivative will be negative.

Proof of Corollary 2. Inequality (14) describes a sufficient condition for strict concavity of i's objective function, which guarantees existence of pure-strategy equilibria. It is obtained from i's second-order condition assuming that it holds in the most restrictive case. Here, we use the fact that the density g_i attains its maximum at μ_{δ_i}.

Player i will choose the corner solution $f_i^*=0$ if the derivative of its objective function is negative at $f_i=0$. From (15) we know that this is the case exactly if

$$\eta_H-(\eta_H+\eta_L)\,G_i(\Psi_i)<0. \tag{A.2}$$

As assumption $\eta_H \geq |\eta_L|$ implies that $\eta_H + \eta_L \geq 0$, condition (A.2) may hold or not. Hence, only if $(\eta_H + \eta_L)\, G_i(\Psi_i)$ exceeds η_H, i.e., if Ψ_i becomes large, inequality (A.2) will be satisfied. Note that Ψ_i can indeed become arbitrarily large, for example if $\bar{q}_{j0} > \bar{q}_{i0}$ and both means substantially differ. If the condition for a corner solution does not hold, an interior solution will exist, being described by equation (15).

Proof of Proposition 3. As δ_i is normally distributed with mean $\Sigma_i \bar{q}_{i0} - \Sigma_j \bar{q}_{j0}$ and variance $\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2$, equation (15) can be rewritten as

$$\beta \Sigma_i \left[\eta_H - (\eta_H + \eta_L)\, \Phi \left(\frac{\bar{q}_{j0} - \bar{q}_{i0}}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}} \right) \right] = c'(f_i^*) \tag{A.3}$$

with Φ as cdf of the standard normal distribution. The derivative with respect to β of the left-hand side will be positive iff

$$\begin{aligned}
&\left[\Sigma_i - \frac{2\beta^2 \sigma_{i0}^2 \sigma_\varphi^2}{\left(\beta^2 \sigma_\varphi^2 + \sigma_{i0}^2\right)^2} \right] \left[\eta_H - (\eta_H + \eta_L)\, \Phi \left(\frac{\bar{q}_{j0} - \bar{q}_{i0}}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}} \right) \right] \\
&+ (\eta_H + \eta_L)\, \beta \Sigma_i \phi \left(\frac{\bar{q}_{j0} - \bar{q}_{i0}}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}} \right) \frac{\bar{q}_{i0} - \bar{q}_{j0}}{\left(\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2\right)^{\frac{3}{2}}} \left(\Sigma_i^2 + \Sigma_j^2\right) \beta \sigma_\varphi^2 > 0 \\
\Leftrightarrow &\frac{\sigma_{i0}^2 - \beta^2 \sigma_\varphi^2}{\beta^2 \sigma_\varphi^2 + \sigma_{i0}^2} \left[\eta_H - (\eta_H + \eta_L)\, \Phi \left(\frac{\bar{q}_{j0} - \bar{q}_{i0}}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}} \right) \right] \\
&+ (\eta_H + \eta_L)\, \beta \phi \left(\frac{\bar{q}_{j0} - \bar{q}_{i0}}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}} \right) \frac{(\bar{q}_{i0} - \bar{q}_{j0})\, \beta \sigma_\varphi^2}{\left(\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2\right)^{\frac{3}{2}}} \left(\Sigma_i^2 + \Sigma_j^2\right) > 0.
\end{aligned} \tag{A.4}$$

We are looking for values of initial heterogeneity as measured by $\bar{q}_{i0} - \bar{q}_{j0}$ such that this inequality is fulfilled. First, note that for $\bar{q}_{i0} - \bar{q}_{j0} > 0$ the competition effect of player i (i.e., the second line of (A.4)) is positive. Moreover, in the first line of inequality (A.4), the first term is positive by assumption and the second term is positive in any interior equilibrium so that the information effect is positive as well. Hence, the inequality is fulfilled. Suppose now $\bar{q}_{i0} - \bar{q}_{j0} < 0$. In this case, the competition effect of player i is strictly negative. To show the existence of χ_i^{affine}, we follow two steps.

Step 1: The competition effect can dominate the information effect

Suppose $\eta_L > 0$. Consider initial heterogeneity $\bar{q}_{i0} - \bar{q}_{j0} < 0$ small enough such that $\Phi(\cdot)$ is almost equal to $\frac{\eta_H}{\eta_H + \eta_L}$. In this case, the information effect becomes arbitrarily small while the competition effect remains strictly negative. Hence, the effect of β on fake news intensity will be strictly negative. For any value of heterogeneity such that $\Phi(\cdot)$ is larger than $\frac{\eta_H}{\eta_H+\eta_L}$, player i will choose $f_i = 0$ and the effect will be zero. Now, suppose $\eta_L < 0$. In that case, a corner solution with $f_i = 0$ cannot exist. If $\bar{q}_{i0} - \bar{q}_{j0} \to -\infty$, the information effect converges to $\frac{\sigma_{i0}^2-\beta^2\sigma_\varphi^2}{\beta^2\sigma_\varphi^2+\sigma_{i0}^2}\eta_H > 0$, whereas the competition effect converges to $-\infty$ so that the overall effect of β on fake news intensity is strictly negative. ||

Step 2: The competition effect has only one root in $\bar{q}_{i0} - \bar{q}_{j0}$

To prove this claim consider the derivative of the left-hand side of (A.4) with respect to $\bar{q}_{i0} - \bar{q}_{j0}$:

$$\begin{aligned}
&\frac{\sigma_{i0}^2 - \beta^2\sigma_\varphi^2}{\beta^2\sigma_\varphi^2 + \sigma_{i0}^2}\frac{\eta_H + \eta_L}{\sqrt{\Sigma_i\sigma_{i0}^2 + \Sigma_j\sigma_{j0}^2}}\phi\left(\frac{\bar{q}_{j0} - \bar{q}_{i0}}{\sqrt{\Sigma_i\sigma_{i0}^2 + \Sigma_j\sigma_{j0}^2}}\right) \\
-&\left(\eta_H + \eta_L\right)\beta\phi'\left(\frac{\bar{q}_{j0} - \bar{q}_{i0}}{\sqrt{\Sigma_i\sigma_{i0}^2 + \Sigma_j\sigma_{j0}^2}}\right)\frac{\left(\bar{q}_{i0} - \bar{q}_{j0}\right)\beta\sigma_\varphi^2}{\left(\Sigma_i\sigma_{i0}^2 + \Sigma_j\sigma_{j0}^2\right)^2}\left(\Sigma_i^2 + \Sigma_j^2\right) \\
+&\left(\eta_H + \eta_L\right)\beta\phi\left(\frac{\bar{q}_{j0} - \bar{q}_{i0}}{\sqrt{\Sigma_i\sigma_{i0}^2 + \Sigma_j\sigma_{j0}^2}}\right)\frac{\beta\sigma_\varphi^2}{\left(\Sigma_i\sigma_{i0}^2 + \Sigma_j\sigma_{j0}^2\right)^{\frac{3}{2}}}\left(\Sigma_i^2 + \Sigma_j^2\right).
\end{aligned}$$

Using that $\phi'(x) = -x\phi(x)$, this expression will be positive if and only if

$$\frac{\sigma_{i0}^2 - \beta^2\sigma_\varphi^2}{\beta\left(\Sigma_i^2 + \Sigma_j^2\right)\left(\beta^2\sigma_\varphi^2 + \sigma_{i0}^2\right)} - \frac{\left(\bar{q}_{i0} - \bar{q}_{j0}\right)^2\beta\sigma_\varphi^2}{\left(\Sigma_i\sigma_{i0}^2 + \Sigma_j\sigma_{j0}^2\right)^2} + \frac{\beta\sigma_\varphi^2}{\Sigma_i\sigma_{i0}^2 + \Sigma_j\sigma_{j0}^2} > 0.$$

Hence, the derivative is positive if and only if $|\bar{q}_{i0}-\bar{q}_{j0}|$ is small. The result from step 1 further implies that the overall effect of β on fake news intensity converges to a negative value for $\bar{q}_{i0} - \bar{q}_{j0}$ sufficiently small. Moreover, the effect is positive at $\bar{q}_{i0} - \bar{q}_{j0} = 0$ and remains positive for larger differences. Summing up, the effect is negative at some negative values for $\bar{q}_{i0} - \bar{q}_{j0}$, it increases monotonically in an interval around 0 (and decreases everywhere else), becomes positive and remains positive thereafter. Hence, there can only be one root. ||

Taking steps 1 and 2 together implies the existence of a threshold χ_i^{affine} such that player i will (weakly) increase his fake news intensity as a response to more rigorous institutions – i.e., $\partial f_i^*/\partial\beta \leq 0$ – if and only if $\bar{q}_{i0} - \bar{q}_{j0} < \chi_i^{\text{affine}}$.

Proof of Proposition 4. For part (i) assume that $\eta_L > 0$. First, note that for sufficiently negative $\bar{q}_{i0} - \bar{q}_{j0}$ the fake news intensity of player i will always be zero under an affine payoff structure. In contrast, fake news will always be positive under a constant payoff structure. Hence, $\Delta_i < 0$ for all $\bar{q}_{i0} - \bar{q}_{j0}$ such that a corner equilibrium is attained under affine payoffs. Next, consider Δ_i for interior equilibria. In this case, it is given by

$$\begin{aligned}\Delta_i &= \eta_H - (\eta_H + \eta_L) G_i(\Psi_i) - (\bar{u}_H - \bar{u}_L) g_i(\Psi_i) \\ &= \eta_H - (\eta_H + \eta_L) \Phi\left(\frac{-(\bar{q}_{i0} - \bar{q}_{j0})}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}}\right) - \frac{\bar{u}_H - \bar{u}_L}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}} \phi\left(\frac{-(\bar{q}_{i0} - \bar{q}_{j0})}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}}\right).\end{aligned}$$

The derivative with respect to $\bar{q}_{i0} - \bar{q}_{j0}$ yields

$$\frac{\eta_H + \eta_L}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}} \phi\left(\frac{-(\bar{q}_{i0} - \bar{q}_{j0})}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}}\right) + \frac{\bar{u}_H - \bar{u}_L}{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2} \phi'\left(\frac{-(\bar{q}_{i0} - \bar{q}_{j0})}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}}\right).$$

By using the property $\phi'(x) = -x\phi(x)$ of the standard normal density ϕ, the derivative will be positive iff

$$\begin{aligned}\frac{\eta_H + \eta_L}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}} + \frac{\bar{u}_H - \bar{u}_L}{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2} \frac{\bar{q}_{i0} - \bar{q}_{j0}}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}} > 0 \Leftrightarrow \\ \eta_H + \eta_L + \frac{\bar{u}_H - \bar{u}_L}{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2} (\bar{q}_{i0} - \bar{q}_{j0}) > 0.\end{aligned} \tag{A.5}$$

We conclude that the derivative will be positive if and only if $\bar{q}_{i0} - \bar{q}_{j0}$ is sufficiently large. Hence, Δ_i will be monotonically increasing starting from one point onwards and will be negative before that point. Therefore, there can exist at most one ξ such that Δ_i is positive if and only if $\bar{q}_{i0} - \bar{q}_{j0} > \xi$. To show that ξ exists, it suffices to show that $\lim_{\bar{q}_{i0} - \bar{q}_{j0} \to \infty} \Delta_i > 0$, which is obviously true.

For (ii) and (iii) suppose that $\eta_L < 0$. Hence, the equilibrium will always be interior. For $|\bar{q}_{i0} - \bar{q}_{j0}| \to \infty$, the fake news intensity of i will converge to zero under constant payoffs and to some positive value under affine payoffs. However, there will nevertheless be an interval of values for $\bar{q}_{i0} - \bar{q}_{j0}$ such that i's fake news intensity is higher under constant payoffs. To see this, we make use of (A.5), which implies that the minimum of Δ_i will be given by

$$\eta_H - (\eta_H + \eta_L) \Phi\left(\frac{\eta_H + \eta_L}{\bar{u}_H - \bar{u}_L} \sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}\right) - \frac{\bar{u}_H - \bar{u}_L}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}} \phi\left(\frac{\eta_H + \eta_L}{\bar{u}_H - \bar{u}_L} \sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}\right). \tag{A.6}$$

For $\eta_L = 0$ this term is

$$\eta_H \left[1 - \Phi\left(\frac{\eta_H}{\bar{u}_H - \bar{u}_L}\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}\right)\right] - \frac{\bar{u}_H - \bar{u}_L}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}}\phi\left(\frac{\eta_H}{\bar{u}_H - \bar{u}_L}\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}\right) < 0$$

$$\Leftrightarrow \frac{\eta_H}{\bar{u}_H - \bar{u}_L}\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}\left[1 - \Phi\left(\frac{\eta_H}{\bar{u}_H - \bar{u}_L}\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}\right)\right] - \phi\left(\frac{\eta_H}{\bar{u}_H - \bar{u}_L}\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}\right) < 0.$$

We know that this inequality is fulfilled since the hazard rate of the standard normal distribution is larger than its argument at any positive argument (see, for example, Baricz, 2008). From (A.5), we know that Δ_i decreases until it reaches its minimum and increases afterward. With $\lim_{|\bar{q}_{i0} - \bar{q}_{j0}| \to \infty} \Delta_i > 0$, it is therefore clear that there exist two thresholds ξ' and ξ'' such that Δ_i is positive if and only if $\bar{q}_{i0} - \bar{q}_{j0} \notin [\xi', \xi'']$, which establishes (ii) for values of η_L close to zero.

Moreover, the minimum of Δ_i in (A.6) is differentiable in η_L with derivative

$$- \Phi\left(\frac{\eta_H + \eta_L}{\bar{u}_H - \bar{u}_L}\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}\right) - (\eta_H + \eta_L)\,\phi\left(\frac{\eta_H + \eta_L}{\bar{u}_H - \bar{u}_L}\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}\right)\frac{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}}{\bar{u}_H - \bar{u}_L} - \phi'\left(\frac{\eta_H + \eta_L}{\bar{u}_H - \bar{u}_L}\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}\right).$$

By using the property $\phi'(x) = -x\phi(x)$, the derivative is given by

$$- \Phi\left(\frac{\eta_H + \eta_L}{u_H - u_L}\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}\right),$$

which is negative. Hence, there will exist two thresholds ξ' and ξ'' such that Δ_i is positive if and only if $\bar{q}_{i0} - \bar{q}_{j0} \notin [\xi', \xi'']$ for all values of η_L larger than some negative threshold $\bar{\eta}_L$, which establishes (ii).

To establish (iii), the only step that remains to be shown is whether $\bar{\eta}_L$ will be larger than the smallest possible value of η_L which is, by assumption, given by $-\eta_H$, or whether (ii) holds for all negative values of η_L. The threshold $\bar{\eta}_L$ will be larger than $-\eta_H$ if and only if the minimum of Δ_i (given by (A.6)) evaluated at $\eta_L = -\eta_H$ is positive:

$$\eta_H - \frac{\bar{u}_H - \bar{u}_L}{\sqrt{\Sigma_i \sigma_{i0}^2 + \Sigma_j \sigma_{j0}^2}}\phi(0) > 0.$$

If this is the case, the minimum of Δ_i is positive for all $\eta_L < \bar{\eta}_L$, and for all $\eta_L \in [\bar{\eta}_L, 0)$ the minimum will be negative. In the former case, Δ_i is always positive.

B. DERIVATION OF THE EQUILIBRIUM IN THE MODIFIED TULLOCK CONTEST

Denote player i's own money that is spent in the campaign by x_i, and define $\Lambda := \bar{q}_{i1} - \bar{q}_{j1} > 0$. Altogether, player i invests $\gamma \cdot \Lambda + x_i > 0$ into campaigning, which costs him x_i. Player j, however, can only spend own money, $x_j > 0$. The player with the better performance wins. Let the strong player i's performance be described by $y_i = \omega_i \cdot (\gamma\Lambda + x_i)$ and that of the weak player j by $y_j = \omega_j \cdot x_j$ with ω_i and ω_j being i.i.d. and following an exponential distribution over $[0, \infty]$ with cdf $1 - \exp\{-\lambda\omega\}$ and hazard rate $\lambda > 0$.

Player i will be selected if $y_i > y_j$, and player j if $y_i < y_j$. The player that has successfully run for office or convinced the decision maker to implement his project gets the benefit $B > 0$ (e.g., high income, prestige, power), whereas the other player gets zero. To sum up, at stage two, player i chooses x_i to maximize his payoff $\pi_i(x_i) =$prob$\{\omega_i \cdot (\gamma\Lambda + x_i) > \omega_j \cdot x_j\} \cdot B - x_i$, whereas player j simultaneously decides on x_j to maximize $\pi_j(x_j) =$prob$\{\omega_i \cdot (\gamma\Lambda + x_i) < \omega_j \cdot x_j\} \cdot B - x_j$.

Player i's probability of winning the competition is given by

$$\text{prob}\{y_i > y_j\} = \text{prob}\left\{\omega_j < \omega_i \frac{\gamma\Lambda + x_i}{x_j}\right\}$$
$$= \int_0^\infty \left[1 - \exp\left\{-\lambda\omega_i \frac{\gamma\Lambda + x_i}{x_j}\right\}\right] f(\omega_i)\, d\omega_i \tag{B.1}$$

with $f(\omega) = \lambda \exp\{-\lambda\omega\}$ as exponential density function. Expression (B.1) can be rewritten as

$$\int_0^\infty \left[f(\omega_i) - \exp\left\{-\lambda\omega_i \frac{\gamma\Lambda + x_i}{x_j}\right\} \lambda \exp\{-\lambda\omega_i\}\right] d\omega_i$$
$$= \int_0^\infty \left[f(\omega_i) - \lambda \exp\left\{-\lambda\omega_i \frac{\gamma\Lambda + x_i + x_j}{x_j}\right\}\right] d\omega_i$$
$$= \int_0^\infty f(\omega_i)\, d\omega_i + \left[\frac{x_j}{\gamma\Lambda + x_i + x_j} \exp\left\{-\lambda\omega_i \frac{\gamma\Lambda + x_i + x_j}{x_j}\right\}\right]_0^\infty$$
$$= 1 - \frac{x_j}{\gamma\Lambda + x_i + x_j} = \frac{\gamma\Lambda + x_i}{\gamma\Lambda + x_i + x_j},$$

which is identical to the contest-success function of Tullock (1980) for our modified setting with a lead. Accordingly, player j's probability of winning reads as $x_j/(\gamma\Lambda + x_i + x_j)$.

Players i and j thus maximize

$$\pi_i(x_i) = \frac{\gamma\Lambda + x_i}{\gamma\Lambda + x_i + x_j} \cdot B - x_i \quad \text{and} \quad \pi_j(x_j) = \frac{x_j}{\gamma\Lambda + x_i + x_j} \cdot B - x_j, \tag{B.2}$$

respectively. Both objective functions are strictly concave. The two first-order conditions lead to

$$\frac{B}{(\gamma\Lambda + x_i + x_j)^2} = \frac{1}{x_j} = \frac{1}{\gamma\Lambda + x_i},$$

yielding the Nash equilibrium $(x_i^*, x_j^*) = (\frac{B}{4} - \gamma\Lambda, \frac{B}{4})$.[21] Inserting into (B.2) and replacing Λ by $\bar{q}_{i1} - \bar{q}_{j1}$ gives the players' equilibrium payoffs (16) (which are identical to (12) and (13) with $\bar{\eta} = B/4$, $\eta_H = \gamma$, and $\eta_L = 0$).

In an alternative setting, we can think of player i's posterior lead Λ being split up into a relative advantage $\frac{1}{2}\gamma\Lambda$ for i and a relative disadvantage $-\frac{1}{2}\gamma\Lambda$ for j. Then, equilibrium payoffs will be

$$\pi_i^* = \frac{B}{4} + \frac{1}{2}\gamma \cdot (\bar{q}_{i1} - \bar{q}_{j1}) \quad \text{and} \quad \pi_j^* = \frac{B}{4} - \frac{1}{2}\gamma \cdot (\bar{q}_{i1} - \bar{q}_{j1}) \,. \tag{B.3}$$

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[21] Recall that we allow for $x_i < 0$ (i.e., candidate i saves money) as long as $\gamma\Lambda + x_i > 0$.

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C. ONLINE APPENDIX

C.1. Payoffs in the All-Pay Auction with Quality-Dependent Winner Prize

As an alternative to a Tullock contest, suppose that the winner is selected according to the decision rule of the all-pay auction, i.e., player i will win if $x_i > x_j$, whereas j will win if $x_i < x_j$. In addition, consider a situation in which the players' posterior expected qualities at the beginning of stage two, $\bar{q}_{i1}$ and $\bar{q}_{j1}$, do not influence additional external funding but the players' individual benefits from winning the competition. Imagine, for example, that a more able politician has a higher utility from being elected than a less able one as the former does not have to substitute ability with effort and, hence, does not have to bear high opportunity costs of time to do a satisfactory job. Or imagine that politicians with higher perceived ability or a higher perceived quality of their agenda face less resistance and have more support when implementing their political plans. In all these situations, instead of a common benefit from being elected, B, there exist individual benefits that increase with expected quality. Let, e.g., $B_i = \gamma \cdot \bar{q}_{i1}$ describe player i's benefit from being elected and $B_j = \gamma \cdot \bar{q}_{j1}$ that of player j, with $\bar{q}_{i1} > \bar{q}_{j1}$. Again, players are assumed to simultaneously spend resources x_i and x_j.

Then, as the results of Hillman and Riley (1989) and Baye *et al.* (1996) show, the players' stage-two payoffs in our game are

$$\pi_i^* = \gamma \cdot (\bar{q}_{i1} - \bar{q}_{j1}) \quad \text{and} \quad \pi_j^* = 0. \tag{C.1}$$

According to Baye *et al.* (1996), the described all-pay auction is strategically equivalent to an all-pay auction with common benefit B, but individual costs of campaigning, $c_i \cdot x_i$ with $c_i = 1/\bar{q}_{i1}$. In that case, the game can be reinterpreted as a game where the players do not possess own money but have to bear personal costs $c_i \cdot x_i$ for acquiring external funding x_i. Intuitively, it is easier for a player with higher perceived ability to raise funds than for a player with lower perceived ability.

C.2. Market Equilibrium in the Price Competition Game

We start by constructing the demand functions of the consumers for given prices p_i and p_j and given posterior expected qualities $\bar{q}_{i1}$ and $\bar{q}_{j1}$ ($< \bar{q}_{i1}$). The expected utility of a consumer k of type θ_k buying good i reads as

$$u_k = \theta_k \bar{q}_{i1} - p_i.$$

Since we assume that the market is fully covered, consumer k will buy good i if and only if

$$\theta_k \bar{q}_{i1} - p_i \geq \theta_k \bar{q}_{j1} - p_j \Leftrightarrow \theta_k \geq \frac{p_i - p_j}{\bar{q}_{i1} - \bar{q}_{j1}}.$$

As θ is uniformly distributed with cumulated distribution function $F(\theta) = \theta - \bar{\theta} + 1 \Leftrightarrow 1 - F(\theta) = \bar{\theta} - \theta$, the demand for good i is described by

$$D_i(p_i, p_j) = \begin{cases} \bar{\theta} - \frac{p_i - p_j}{\bar{q}_{i1} - \bar{q}_{j1}} & \text{if} \quad p_i \geq p_j + (\bar{\theta} - 1)(\bar{q}_{i1} - \bar{q}_{j1}) \\ 1 \quad \text{otherwise.} \end{cases}$$

The maximizer of the profit function $p_i D_i(p_i, p_j)$, given $p_i \geq p_j + (\bar{\theta} - 1)(\bar{q}_{i1} - \bar{q}_{j1})$, is

$$p_i = \frac{p_j + (\bar{q}_{i1} - \bar{q}_{j1})\bar{\theta}}{2}.$$

This maximizer will be larger than the cutoff for the demand function if

$$\frac{p_j + (\bar{q}_{i1} - \bar{q}_{j1})\bar{\theta}}{2} > p_j + (\bar{\theta} - 1)(\bar{q}_{i1} - \bar{q}_{j1}) \quad \Leftrightarrow \quad (\bar{q}_{i1} - \bar{q}_{j1})(2 - \bar{\theta}) > p_j.$$

As the objective function is concave, the best response of firm i is given by

$$p_i = \begin{cases} \frac{p_j + (\bar{q}_{i1} - \bar{q}_{j1})\bar{\theta}}{2} & \text{if} \quad (\bar{q}_{i1} - \bar{q}_{j1})(2 - \bar{\theta}) > p_j \\ p_j + (\bar{\theta} - 1)(\bar{q}_{i1} - \bar{q}_{j1}) & \text{otherwise.} \end{cases} \tag{C.2}$$

As we have full market coverage, firm j serves the remaining market share $1 - D_i(p_i, p_j)$. Hence, the demand for good j is given by

$$D_j(p_j, p_i) = \begin{cases} \frac{p_i - p_j}{\bar{q}_{i1} - \bar{q}_{j1}} - (\bar{\theta} - 1) & \text{if} \quad p_j \leq p_i - (\bar{\theta} - 1)(\bar{q}_{i1} - \bar{q}_{j1}) \\ 0 \quad \text{otherwise.} \end{cases}$$

The maximizer of firm j's profit function for the situation where $p_j \leq p_i - (\bar{\theta} - 1)(\bar{q}_{i1} - \bar{q}_{j1})$ is

$$p_j = \frac{p_i - (\bar{q}_{i1} - \bar{q}_{j1})(\bar{\theta} - 1)}{2}.$$

This in turn will be smaller than the cutoff for the corresponding demand function if

$$\frac{p_i - (\bar{q}_{i1} - \bar{q}_{j1})(\bar{\theta} - 1)}{2} \leq p_i - (\bar{\theta} - 1)(\bar{q}_{i1} - \bar{q}_{j1}) \quad \Leftrightarrow \quad p_i \geq (\bar{\theta} - 1)(\bar{q}_{i1} - \bar{q}_{j1}).$$

If the maximizer is larger than zero, firm j will price its good accordingly. For $p_i \leq (\bar{\theta} - 1)(\bar{q}_{i1} - \bar{q}_{j1})$, firm j does not get any share of the market for positive prices. Thus, the best response of firm j is

$$p_j = \begin{cases} \frac{p_i - (\bar{q}_{i1} - \bar{q}_{j1})(\bar{\theta} - 1)}{2} & \text{if} \quad p_i \geq (\bar{\theta} - 1)(\bar{q}_{i1} - \bar{q}_{j1}) \\ p_j \in \Re^+ \quad \text{otherwise.} \end{cases} \tag{C.3}$$

We have an interior equilibrium being described by the firms' best responses (C.2) and (C.3). Note that there is no equilibrium in which firm j is indifferent between prices. Firm j will be indifferent only if $p_i < (\bar{q}_{i1} - \bar{q}_{j1})(\bar{\theta} - 1)$. However, the best-response function of player i is above this value for any positive price p_j. Moreover, the best-response functions can only intersect once, since the slope of p_i in p_j is lower than 1 and the slope of p_j in p_i is $\frac{1}{2}$ (i.e., it is 2 in the (p_i, p_j)-plane). The best-response functions intersect at p_j with

$$2p_j + (\bar{q}_{i1} - \bar{q}_{j1})(\bar{\theta} - 1) = \frac{p_j + (\bar{q}_{i1} - \bar{q}_{j1})\bar{\theta}}{2}.$$

As a result, we get equilibrium prices and profits for both firms:

$$p_i = \frac{(\bar{q}_{i1} - \bar{q}_{j1})(\bar{\theta} + 1)}{3} \qquad p_j = \frac{(\bar{q}_{i1} - \bar{q}_{j1})(2 - \bar{\theta})}{3}$$
$$\pi_i = \frac{(\bar{q}_{i1} - \bar{q}_{j1})(\bar{\theta} + 1)^2}{9} \qquad \pi_j = \frac{(\bar{q}_{i1} - \bar{q}_{j1})(2 - \bar{\theta})^2}{9}.$$