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The Logic of Relative Frustration: Boudon's Competition Model and Experimental Evidence

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An improvement in the availability of opportunities for actors in a social system (e.g. a society or a firm) can coincide with a growing rate of frustrated individuals. For instance, uprisings have repeatedly been preceded by forms of political liberalisation that have actually provided greater opportunities (the so-called *Tocqueville paradox)*. In organisations, satisfaction with regard to promotion opportunities can be negatively associated with objective chances of promotion. Raymond Boudon has proposed a game-theoretic competition model which specifies the micro-mechanisms that produce these puzzling phenomena at the aggregate level, and clarifies the conditions under which they emerge. We conducted three laboratory experiments to test the model's predictions, making our study the first empirical test of Boudon's model. The results are mixed: when opportunities increased, the rate of the relatively frustrated losers in the group remained constant, or increased only slightly. However, when applying another aggregation rule, which accounts for all social comparison processes and does not merely focus on the losers an increase in relative frustration under improved conditions was observed. Our results imply that under specific conditions there is a trade-off between opportunities and social mobility, on the one hand, and social inequality and relative frustration, on the other.

Keywords: game theory, laboratory experiment, relative deprivation, social inequality, social mobility, Tocqueville's paradox, winner-take-all

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Introduction

Surprisingly, an improvement in a society's opportunity structure can coincide with a larger number of frustrated individuals. The first to discuss this phenomenon was Tocqueville, who claimed that the outbreak of the French Revolution was triggered by economic and social improvements. The more prosperity grew, the more frustration spread among the French, with dissatisfaction the strongest in regions where there had been the most dramatic improvements. According to Tocqueville, history is full of such paradoxes: A regime is usually not overturned during the times of hardest suppression but rather during reforms (Tocqueville 1952 [1856]). The factual truth of his historical account is not an issue here, but his thesis is of general interest in the social sciences.[1] The phenomenon that political reforms or economic improvements can lead to an increase in the share of the frustrated and, with a certain probability, to uprisings is called *Tocqueville's paradox* (Neckel 2010).

According to Brinton (1965), the English, American, and Russian revolutions also broke out in keeping with Tocqueville's hypothesis (Brinton 1965).[2] Coleman (1990) discusses more recent examples. For instance, the overthrow of the Shah in Iran came about during times of growing prosperity and the uprising of black South Africans occurred after their disposable incomes rose considerably. The most current example is Brazil. Even though recent reforms have improved the situation of broad social strata that include the poor, massive political protest came about in 2013 (Soares 2013). Moreover, it seems that the Chinese government fears to be next: Tocqueville's oeuvre has become popular among the party elite since the start of the economic liberalization (Pei 2013).

Related to the Tocqueville paradox is Durkheim's observation of rising suicide rates during rapid economic growth (Durkheim 1952 [1897]). Recent cross-sectional studies also conclude that suicide rates are higher in more prosperous countries (Oswald 1997, see also Daly et al. 2010). Nevertheless, as in the case of uprisings after reforms, there are also other examples. For instance, in Germany suicide rates have declined considerably with growing prosperity.[3]

The effect of more dissatisfaction under improved circumstances does not only appear on the societal level but also within organizations. In their almost classic study on social mobility in the US army, Stouffer et al. (1965 [1949]) came to the astonishing result that satisfaction with promotion chances was lower in branches with high objective opportunities. Not less interesting examples are discussed by Gladwell (2013).

Boudon (1988, 1986, 1982) presents a game-theoretic model that explains the puzzle of more frustration under improving (or better) conditions as the consequence of rational individual decisions in interdependent competition situations.[4] As the opportunity structure in a social system improves, competition becomes fiercer, leading to more frustration.[5]

Although Boudon's competition model has been discussed (Gambetta 2005; Neckel 2010), extended (Kosaka 1986; Raub 1984; Yamaguchi 1998), and implemented as a computer simulation (Manzo 2011, 2009), as far as we are aware there has never been an empirical test of the central model implications. To fill this gap, we conducted three laboratory experiments testing the central hypothesis of an increasing rate of relative frustration under improved conditions.

The remainder of this article is organized as follows: The next section outlines the model and its implications. Additionally, testable hypotheses are formulated. Subsequently, we present the experimental design and procedures and, in the on-following section, the results. We conclude with a discussion of the findings and their implications, and suggest further research directions.

Boudon's Competition Model and Hypotheses

Boudon's game-theoretic model describes the rate of relative frustration in a social system as a function of the opportunity structure in interdependent competition situations. Under specific parameter constellations, already a small improvement in the opportunity structure can tempt a large number of individuals to invest their resources in a competition for a scarce and lucrative good. If the number of investors grows significantly faster than the opportunities, a substantial number of investors lose their resources. The losers are relatively deprived, or in Boudon's words, *relatively frustrated*.[6]

The model

Starting point are N actors facing the decision whether or not to invest resources C such as time, effort, or money in a competition for a scarce and highly valued good, for instance a high-prestige position within a firm. There are k opportunities (positions) and n investors. Because the good is scarce, it must hold that $k < N$.[7] While k is common knowledge, the number of investors can range from 0 to N. Successful investors get access to the scarce good (e.g., promotion) and therefore receive the high payoff α, which is given by gross benefit B (e.g., prestige, power or money) minus investment costs C (see Figure 1; see also Hedström 2005: 57). In the case of a university student, C might be time and money invested in education in order to receive a well-paid job, while other members of her cohort have already entered the labour market.

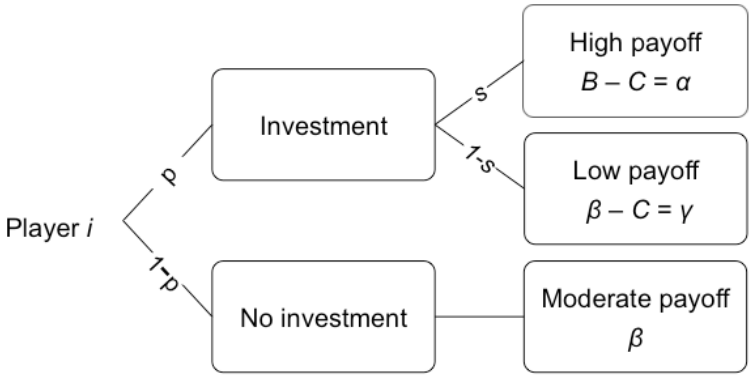

Figure 1: Individual decision situation: The strategy 'investment' is risky and leads to the high payoff α with probability s and to the low payoff γ with probability 1 – s. The strategy 'no investment' leads to the medium payoff β with certainty.

Since the probability of success depends on the total number of investors, the investment decision is strategic in nature. If the number of investors n exceeds the amount of free positions k, some investors necessarily fail to obtain a desired position. Even though they have invested the same amount of C as the successful *winners*, the *losers* get nothing in return and are, as a result, relatively frustrated (or relatively deprived) in relation to the winners. This is represented by the low payoff γ, which is given by the status quo minus C. A well-known real-life example is the taxi driver with a university degree (see Peiró, Agut and Grau 2010). *Sustainers* (non-investors), e.g., individuals deciding to enter the labour market early and not to compete for lucrative but scarce positions, will neither get a high-prestige job nor will they lose any resources. They consequently end up with the moderate payoff β. Formally, the payoffs satisfy the inequalities $\alpha > \beta > \gamma$.

Individual investment decisions depend on the opportunity structure provided by a competition, which is determined by the number of scare positions k and by the cost–benefit ratio Q:

$$Q = \frac{B - \beta}{C}.$$

Q expresses how lucrative the winners' payoff α is in comparison to the sustainers' payoff β, considering the investment costs C.

The probability of success s for a player choosing the strategy 'investment' is given by the ratio of the number of scarce positions k to the number of investors n. This is provided that the number of investors exceeds the number of positions and 1, otherwise:

$$s = \begin{cases} \frac{k}{n} & \text{for } k < n \\ 1 & \text{for } k \geq n. \end{cases}$$

Note, that all N players decide simultaneously whether or not to compete. Hence, before the decisions are made, the actual number of investors n is unknown, while the number of positions k is common knowledge. The higher the number of investors, the lower the chances of success for each player.

Given α, γ, and k the expected payoff $E(k, n)$ for a specific number of investors n is provided by:

$$E(k,n) = \begin{cases} \frac{k}{n}\alpha + \frac{n-k}{n}\gamma & \text{for } k < n \\ \alpha & \text{for } k \geq n. \end{cases} \qquad (1)$$

With this information, the game matrix from the perspective of any player i can be constructed (see Figure 2). In the matrix, the expected payoff of the strategy 'investment' for each possible number of player i's competitors (n –1) is depicted.

		Number of other investors (n – 1)					
		0	1	2	n – 1	...	N – 1
Player i	Investment	$E(k, 0)$	$E(k, 1)$	$E(k, 2)$	$E(k, n-1)$	...	$E(k, N-1)$
	No investment	β	β	β	β	...	β

Figure 2: Game matrix from the perspective of player i. The expected payoff E(k, n) is determined by equation (1).

The model assumptions are in accordance with classical game theory. Each player knows that all players are fully rational and maximize their expected utility. The rules of the game are common knowledge.

So, what will a rational actor do in this situation? If the expected payoff of the strategy 'investment' $E(k, n)$ exceeds the sustainers' payoff β independently of the actual number of investors, 'investment' is the dominant strategy, which means that all players will invest. For the case that no best strategy exists, there is a threshold n^* with the property that, as long as maximally n^* players choose to invest, the expectation of an investment exceeds the payoff β. So there are $\binom{N}{n^*}$ asymmetrical Nash equilibria in pure strategies, in which n^* players choose 'investment' and $N - n^*$ players choose 'no investment'. Nevertheless, since homogeneous actors are assumed, communication is not possible and there is no correlative device, none of these equilibria is likely to be realized. Hence, we argue that the rationality solution lies in mixed strategies, with an optimal

investment probability p^*. The more positions k there are, the higher is the probability that a given player chooses to compete.

The counter-intuitive phenomenon that additional opportunities lead to an increase in relative frustration occurs if a small increase in k tempts an excessive number of players to choose the strategy 'investment' and, as a result, the increase in the loser rate exceeds the number of the additional opportunities substantially. Roughly speaking, this is the case if the benefit of the strategy 'investment' is significantly superior to the one of 'no investment' while the costs of investing are rather low; that is, if Q is sufficiently high.

Model Implications and Hypotheses

We illustrate the discussed mechanisms with two numerical examples. Both of these examples have been implemented experimentally to test model predictions.

a) Mixed Strategy Case

Let there be a social system of $N = 6$ players choosing whether or not to compete for one of k scarce positions. Sustainers receive a moderate payoff $\beta = 6.5$ with certainty. Successful investors receive the high payoff $\alpha = 9$, which is given by gross benefit $B = 10.5$ minus investment costs $C = 1.5$. Losers invest their resources in vain and end up with the low payoff, in this case $\gamma = \beta - C = 5$. The number of promotion opportunities k varies from 1 to 5. In Figure 3, the game matrix for these parameter values and the case

of 1 position is displayed. The payoff of the strategy 'no investment' is fixed at 6.5, while for a given player i the expectation of 'investment' depends on the total number of her competitors $n - 1$ and can be calculated using equation (1). If player i is the only investor, she will get 9 for sure. Of course, the more players enter the competition, the smaller is the expectation value of the strategy 'investment' for any of the investors. Evidently, 'investment' is not a dominant strategy: As soon as two or more other players than i choose to invest, the expected payoff of 'investment' is worse than the payoff of 'no investment'. Hence, a rational actor will apply a mixed strategy.

		Number of other investors ($n - 1$)					
		0	1	2	3	4	5
Player i	invest	9	7	6.3	6	5.8	5.7
	not invest	6.5	6.5	6.5	6.5	6.5	6.5

Figure 3: Game matrix from the perspective of player i. The expected payoff E(k, n) for the strategy 'investment', given the number of player i's competitors (n – 1) is determined by equation (1). Parameter values: k = 1, α = 9, γ = 5, N = 6. The payoff β for 'no investment' is fixed at 6.5.

The optimal mixture of both strategies can be gained by exploiting the principle of indifference. If all players choose to invest with the optimal probability p^*, all players are indifferent between their pure strategies. This results in a Nash equilibrium in mixed strategies (Nash 1950, Gintis 2009, for a game-theoretic analysis of Boudon's model see also Raub 1984). To derive p^*, the overall expected payoff of the strategy 'investment' $E(k,\bullet)$ for a given value of k and all possible permutations of investors is equated with the payoff of the strategy 'no investment' β (see equation (2)). Solving for p yields the optimal investment probability p^*.

$$E(k,\bullet) = \sum_{n=1}^{N} \binom{N-1}{n-1} p^{n-1}(1-p)^{N-n} \cdot E(k,n) = \beta \qquad (2)$$

Given one prestigious position, for the parameter values specified above, the rational solution is to invest with a probability of $p^* = .429$ and to sustain with $1 - p^* = .571$. The expected relative frequency of *investors* then equals p^*.[8] Provided there are more investors than free positions, the share of winners in a social system of N is given by the ratio of free positions to the total number of individuals (k/N), and the loser rate is determined by subtracting the winner rate from the investor rate ($p^* - k/N$). Should the number of investors be lower than the number of positions, every investor wins and the loser rate equals zero. Importantly, Boudon defines the *rate of relative frustration* in a social system as the loser rate, abstracting from the non-investors and winners.

For the discussed parameter constellation, the expected proportions of investors, winners and losers as a function of k are plotted in Figure 4a. If $k = 1$, as derived from equation (2), 42.9% of all players are expected to choose 'investment'. Since there are $(k/N) \cdot 100$ = 16.7% winners, there will be 42.9% – 16.7% = 26.2% losers. When k is doubled from 1 to 2 position, the rate of investors grows sharply by 46.0 percentage points: the increase in opportunities leads to an excessive increase in investors and thus to fiercer competition. As a result, the rate of frustrated losers increases by 29.3 percentage points. This increase is sharper than the increase in the winner rate of 16.7 percentage points. Obviously, there are more additional losers than additional winners, even though the number of positions has doubled from one to two.

If k keeps rising, the rate of the frustrated losers starts decreasing: As soon as one hundred per cent of the population is competing, additional positions can only diminish the rate of the relatively frustrated.

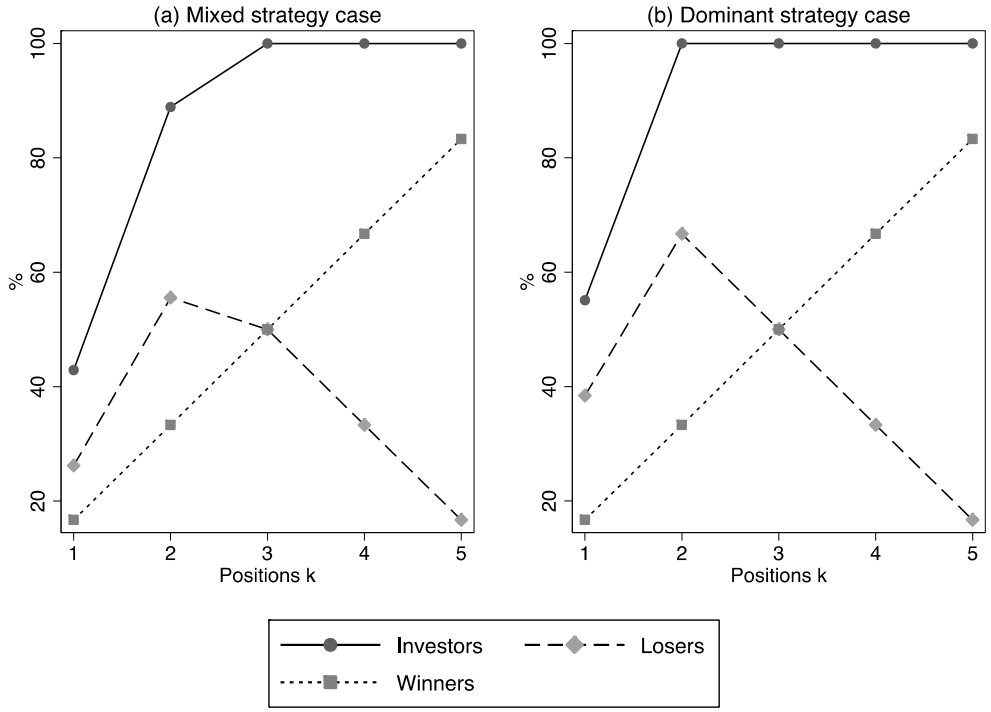

Figure 4: Model predictions: rate of investors, winners and losers in % by number of positions k. (a) Mixed strategy case (b). Dominant strategy case.

In short, the rate of relative frustration follows an inversely U-shaped trajectory with a maximum at k = 2. We call the discussed situation the *mixed strategy case* because the paradoxical effect occurs at k = 2, where an equilibrium in mixed strategies exists.

b) Dominant Strategy Case

In our second example, the winners' payoff α is enhanced from 9 to 10, such that 'investment' is the dominant strategy if there are two or more positions. In this case, weaker rationality assumptions – namely no assumption of actors playing mixed

strategies – are required to deduce the hypothesis of an inversely U-shaped trajectory of relative frustration. Let us call this situation the *dominant strategy case*.

As depicted in Figure 4b, if there is only one prestigious position, 55.1% of all players are predicted to choose 'investment', assuming players apply mixed strategies. Whichever decision rule actors actually follow in case of one opportunity, if there are two positions, 'investment' becomes the dominant strategy and all six players will compete for only two positions. Hence, the level of frustrated losers reaches its maximum (100% – 33.3% = 66.7% compared to 38.4% in the low-mobility system with 1 position). If k keeps rising, more and more investors are promoted, while there are no additional losers. Again, the rate of relative frustration follows an inversely U-shaped functional form with its maximum at $k = 2$.

Applying the competition model to Tocqueville's finding, the model explains the increase in dissatisfaction with an improvement in a society's opportunity structure and, as a consequence, an increase in the competition for lucrative positions. This fierce competition lead to an increase of relative frustration, and the disappointed losers engaged in revolutionary activities.[9] Similarly, in Durkheim's study, competitors who hoped but did not manage to profit from the newly arisen economic chances committed suicide with a higher probability. Finally, in the case of Stouffer's study on promotion chances in the US-Army, the system with one position represents the branches with low promotion chances but a low level of investors and, hence a low level of dissatisfied losers. The system with two positions mirrors branches with more opportunities leading to fierce competition and thus a high loser rate and a low level of aggregate satisfaction.

The model also highlights that the increase in relative frustration under improved chances for upward mobility does not necessarily occur. For instance, if 'investment' is the dominant strategy and all players compete anyway, additional positions k coincide with *fewer* frustrated losers and *more* satisfied winners. Furthermore, if the expected payoff of an investment is not too tempting, additional opportunities lead to an according investment rate, and relative frustration remains constant. Hence, the model implies that, on the aggregate level, there is no universal law connecting opportunities to frustration rates. Depending on the parameter constellation, Pareto optimal improvements can lead to a higher as well as a lower share of frustrated individuals.

As derived from the model, then, only under certain conditions will the effect of a higher rate of frustrated individuals under improved circumstances emerge as the unintended consequence of rational individual decisions. In our experiments, we realized these conditions in order to test the main model prediction of an inversely U-shaped rate of relative frustration. More specifically, we aimed at testing the following hypotheses:

H1: The higher the number of positions, the higher the number of investors according to the predictions of the game-theoretic model.

H2: The rate of the frustrated losers is an inversely U-shaped function of the number of positions.

Experimental Methods

We conducted a series of three laboratory experiments. In the first experiment, we implemented the parameters of the mixed strategy case (the first of the two numerical examples discussed in the preceding session) in a within-subjects design. In experiment 2, we replicated this experiment in a between-subjects design to prevent that decisions depend on the outcomes of preceding competitions. Additionally, we projected the payoffs into the positive domain to eliminate loss-aversion (Kahneman and Tversky 1979). The third experiment is a replica of the second case discussed in the preceding section; that is, the dominant strategy case. In this case, weaker rationality assumptions are necessary to derive the inversely U-shaped path of relative frustration from the model.

Table 1: Parameter values and model predictions in experiments 1, 2 and 3

	Experiment 1			Experiment 2		Experiment 3	
Parameters							
Winners' payoff α			7		9		10
Sustainer' payoff β			1		6.5		6.5
Losers' payoff γ			-3		5		5
Number of positions k			1, 2, 5		1, 2		1, 2
Group size			6		6		6
Predictions							
	$k = 1$	$k = 2$	k = 5	$k = 1$	$k = 2$	$k = 1$	$k = 2$
Investors (%)	39.7	83.3	100	42.9	88.9	55.1	100
Losers (%)	23.0	50.0	16.7	26.2	55.5	38.4	66.7

Note: payoffs in CHF.

In experiment 1, we compared competitions with one position (*low-mobility condition*), two positions (*moderate-mobility condition*), and five positions (*high-mobility condition*)

in order to test the hypothesis of an inversely U-shaped rate of relative frustration. In experiments 2 and 3, we restricted ourselves to the comparison of low-mobility systems to moderate-mobility systems and omitted the high-mobility system to focus on the effect of an increase in the rate of relative frustration under improved conditions. An overview of all parameter values and predictions is given in table 1.

72 students participated in experiment 1, and 60 each in experiments 2 and 3. In all experiments, subjects were randomly assigned to groups of six; separate competitions were held for each group. When all the individuals of a given group had decided whether or not to invest, k winners were chosen randomly from among the investors of the corresponding group. In the first experiment, the participants played the competition game for 6 rounds, while only one round was played in experiments 2 and 3.[10]

Relative frustration in the lab

Test of hypotheses

For all three experiments, we report descriptive statistics that are also visualised in Figure 5. Tests for statistical significance were conducted by means of logit models. The corresponding estimations are listed in Table A1 in the appendix.

In the *first experiment*, as expected, subjects invested with a higher probability as the number of positions was increased (Figure 5a). The investor rate rose from 36.1% in the low-mobility condition (k = 1), to 54.9% in the medium-mobility condition (k = 2), and reached 90.3% in the high-mobility condition (k = 5). Both the investor rate of the low-mobility condition and the investor rate of the high-mobility condition differ significantly from the reference category (k = 2) at least at the 1% significance level. Nevertheless, while predicted and observed values correspond quite well in the cases of one (39.7% predicted, 36.1% observed) and five positions (100% predicted, 90.3% observed), there were notably fewer investors than predicted in the medium-mobility system (83.3% predicted, 54.9% observed). Consequently, as depicted in Figure 5b, the rate of the relatively frustrated losers remained roughly constant as the number of positions was doubled from one position (20.8% losers) to two positions (22.9% losers, p = .748). Finally, and in line with the model, the frustration level of 10.4% was lower in the high-mobility system in comparison to the medium-mobility system (p = .025). In short, no inversely U-shaped rate of relative frustration was observed. Rather, the loser

rate remained constant when the number of positions was doubled and then decreased in the high-mobility condition.

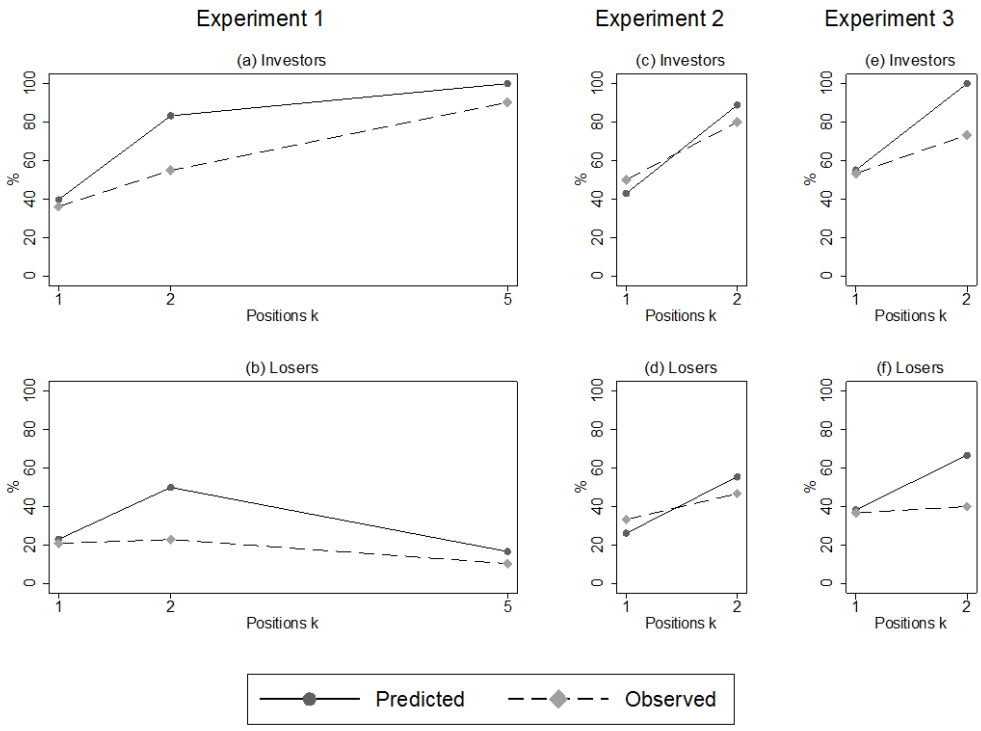

Figure 5: Predicted and observed rates of investors and losers by number of positions for all three experiments.

In the *second experiment*, in the low-mobility condition 50.0% of the subjects chose to invest, while 80.0% entered the competition in the medium-mobility condition. This difference is statistically significant (p = .007) and the observed values approximate the predictions of 42.9% (k = 1) and 88.9% (k = 2) quite well (see Figure 5c). Furthermore, in correspondence with the model, the loser rate of 46.7% in the medium-mobility condition exceeds the loser rate in the low-mobility condition (33.3%, see Figure 5d). However, since more losers than expected were generated in the low-mobility and fewer in the medium-mobility condition, the difference in the loser rate amounts only to 13.3 percentage points, while the model predicts a 29.3 percentage point difference. Because the difference is not even half as large as predicted, it does not reach statistical significance.

In the *third experiment*, 'invest' is the dominant strategy in the medium-mobility system and therefore all six subjects of a given group were predicted to compete for only two positions. Despite this, as depicted in Figure 5e, only 73.3% of all participants entered the competition. Due to this discrepancy, the loser rates did not differ much between the low-mobility condition (36.7%, predicted: 38.4%) and the high-mobility condition (40.0%, predicted: 66.7%, see Figure 5f, $p = .731$).

To sum up, in all three experiments investment increased with the number of positions, which means that hypothesis 1 is supported from a qualitative point of view. Nevertheless, while investment behaviour corresponds neatly with the model at the extreme points of one and five positions, participants invested more cautiously than expected in the medium-mobility condition with two positions. Consequently, frustration remained constant when the number of positions was doubled from one to two (experiments 1 and 3) or increased only slightly (experiment 2). Hypothesis 2 is thus rejected: The rate of the frustrated losers does not follow an inversely U-shaped trajectory but remains constant as positions are enhanced on a low level and decreases in the high-mobility system – a result that lies between model predictions and the naive view of decreasing frustration under improving conditions.

Beyond the loser rate: Gini coefficient

Drawing on the literature on relative frustration discussed in the introduction, we questioned Boudon's narrow focus on the loser rate. While we agree with Boudon that the losers are the only ones being frustrated due to disappointed expectations, the

sustainers might still be relatively frustrated due to a comparison with the winners. Even Boudon acknowledged that even though the sustainers might not be as frustrated as the losers, they most probably are not as satisfied as the winners either (Boudon 1982: 115).[11]

As a measure for relative frustration in a group, the Gini coefficient was suggested (Kakwani 1984). The Gini accounts for all the three types of actors (i.e. losers, winners and sustainers) as well as for the different degree of relative frustration perceived by losers and non-investors by summing up the absolute differences in the payoffs in a group. That is:

$$\sum_{i=1}^{N}\sum_{j=1}^{N} d_{ij},$$

where d_{ij} is the absolute value of the difference in the payoffs between actors i and j. This summation procedure yields, after proper normalisation, the desired measure.[12]

We computed the Gini coefficient predicted by the model and the corresponding empirical values for each experimental condition of experiments 2 and 3 (see Figure 6 and Figure S5, OSD). There are problems with the interpretation of the Gini coefficient in the presence of negative values, however. In order to resolve this, in experiment 1 we calculated the variance as a substitute.[13]

Let us look at the predicted Gini coefficients and variances. In the beginning (k = 1) there are few winners and few losers, and the sustainers prevail – the group composition is

largely equal. When positions increase sharply on a low level (k = 2), the formerly equal sustainers are divided into winners and losers. The dispersion in the payoffs and therefore the number of comparison processes increases. Thereafter, the sustainers vanish, while the losers are diminished. Hence, after a peak, the Gini coefficient declines with increasing positions.

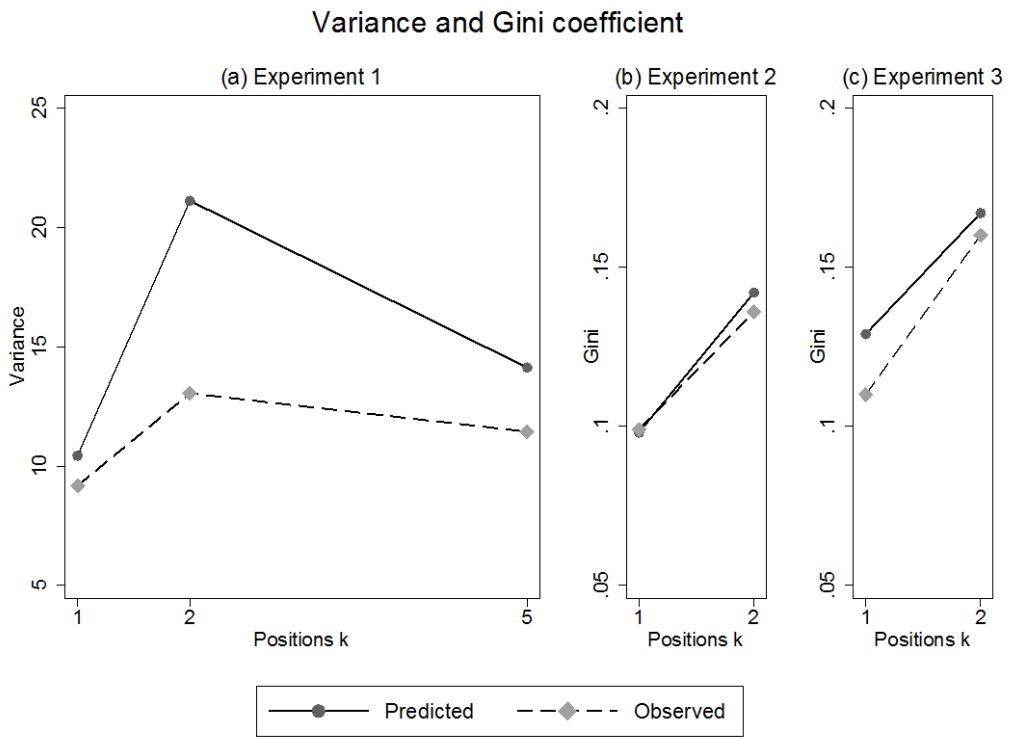

Figure 6: Predicted and observed path of the variance (experiment 1) and the Gini coefficient (experiments 2 and 3).

Not only the predicted, but also the empirical path of the Gini coefficient and the variance is inversely U-shaped – at least in tendency. In *experiment 1*, the variance increases significantly (p = .024) from 9.18 (predicted: 10.44) to 13.05 (predicted: 21.11) and finally decreases to 11.44 (predicted: 14.12), although not statistically significantly (p =. 593).[14] Note that even though the increase in the variance from the low-mobility to the medium-mobility condition is significant, this increase is not as steep as predicted. In *experiment 2*, the Gini rises significantly (p = .006) from .106

(predicted: .098) in the low-mobility condition to .140 (predicted: .142) in the medium-mobility condition. Similar results are observed in *experiment 3*, where the Gini rises from .128 (predicted: .129) to .161 (predicted: .167) when the positions are doubled (p = .025).

In all three experiments, the measures of dispersion increase when the number of positions is doubled and, in tendency, decrease thereafter. It is worth mentioning that this pattern is in line with the *Kuznets curve*. Kuznets (1955) argued that in the course of the economic growth occurring during a society's transition from rural to industrial, the trend of income inequality is inversely U-shaped.

Taken together, our findings suggest that Boudon's explanation of the puzzling phenomena reported by Tocqueville, Durkheim and Stouffer et al. might need revision. While it is true that additional opportunities tempt an increasing share of actors to compete, in none of the three experiments was this increase as sharp as predicted. Consequently, relative frustration, defined as the loser rate, remained constant or increased only slightly when conditions improved on a low level. However, when not merely focusing on the losers and accounting for all comparison processes between losers, sustainers and winners, an increase in relative frustration is observed.

Discussion and Conclusion

An improvement in the opportunity structure of a society (Tocqueville 1952 [1856]) or an organisation (Stouffer et al. 1965 [1949] can lead to an increase in dissatisfaction on the aggregate level. Boudon (1988, 1986, 1982) suggests a game-theoretic model explaining these counterintuitive effects as the unintended consequence of strategic individual decision. As in a social system the chances of getting access to a scarce and lucrative good (e.g., a prestigious position within a firm) increase, then under specific conditions the number of additional investors exceeds the number of additional positions by far. As a consequence of this fierce competition, the rate of the relatively frustrated losers increases – Tocqueville's paradox emerges. When the number of positions is further enhanced, more and more investors achieve promotion, and aggregate frustration diminishes again. In short, the model predicts an inversely U-shaped association between opportunities and relative frustration.

To test the main model predictions, we conducted three laboratory experiments with different parameter values – the first empirical test, as far as we are aware. In accordance with the model, in all three experiments participants invested with a higher probability as the number of opportunities was enhanced. However, especially in the moderate-mobility system, where we expected the rate of the frustrated losers to peak, participants invested more cautiously than predicted. As a consequence, the loser rate remained constant. When conditions further improved, as expected, the loser rate decreased again. This result lies in between model-predictions of an inversely U-shaped rate of frustration and the intuitive belief of a decreasing frustration level under improving conditions.

Post-hoc we questioned Boudon's conception of relative frustration narrowly focusing only on the losers of a competition. Drawing on the received conception of relative frustration resulting from the relative standing of an individual within the group (Stouffer et al. 1965 [1949]) we operationalized relative frustration as the Gini coefficient. In its essence, this measure sums over all differences in the players' payoffs and, in doing so, captures all social comparison processes. Summing over all differences is an alternative aggregation rule, and applying this rule, an inversely U-shaped rate of relative frustration is not only predicted by the model but also found empirically. The observed increase in the Gini coefficient, when chances improve on a low level, was statistically significant in all three experiments. This result is also in line with Kuznets' (1955) thesis of an inversely U-shaped rate of social inequality under improving economic conditions. Note, however, that we derived the inversely U-shaped path of the Gini coefficient from Boudon's model (given a certain combination of parameters). Concerning the micro-macro problem (Coleman 1990) our modification nicely demonstrates the importance of how to transform individual decisions into macro-level effects. Implications of the model on the macro level crucially depend on the proper choice of aggregation rule.

Taken together, our experiments demonstrate that indeed, a more favourable opportunity structure can generate more social inequality, perpetuating social comparison and thus relative frustration. However, as derived from the model, this only can happen when the expected benefit of investing into a competition for upward mobility is considerably larger then the benefit of not doing so and when the increase in

opportunities occurs on a low level. Under these conditions, there can be a trade-off between social mobility and social inequality.

Our study is the first empirical test of Boudon's model and the results should be interpreted with some caution. Future studies should vary parameter values and especially the group size in order to generate more robust results.

Finally, it should be noted that Boudon's competition model is not restricted to investigate relative frustration. Rather it provides a conceptual basis for theoretical and empirical investigations of the interconnection of competition structures, social mobility, status processes, and individual decision behaviour (Bothner et al. 2011; Sauder et al. 2012). The model generalizes "winner-take-all markets" (Frank and Cook 1995; Lutter 2013) and it is a fruitful expansion of classic market-entry models that have been previously used to describe situations such as these (Fischbacher and Thöni 2008). Given the actuality and sociological relevance of these phenomena, it seems worthwhile to further investigate the competition model and exploit it as a theoretical framework for empirical research.

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[1] Tocquville's thesis of an improving economic situation before the French Revolution is controversial. Kruse (2005) states that there was an improvement in economic conditions in the eighteenth century in France but a period of "stagnation" in the 1780s. A bad harvest occurred in 1788, with increasing food prices and hunger revolts immediately before the outbreak of the revolution. See also Hobsbawm (1975), Lindenberg (1989), and Neckel (2010).

[2] More precisely, Brinton states that a gap between rising expectations and actual improvement fostered frustration.

[3] <http://de.statista.com/statistik/daten/studie/583/umfrage/sterbefaelle-durch-vorsaetzliche-selbstbeschaedigung/> (retrieved 24. Feb. 2014).

[4] Alternative explanations and models can be found in Davies (1962), Davis (1959), Elster (1991), and Hirschman and Rothschild (2011).

[5] The model explains variation in relative frustration, with variation in the opportunity structure of a social system. Whether opportunities differ due to changes over time or are cross-sectional is irrelevant.

[6] We tested the micro assumption that the losers are frustrated, that is, less satisfied than the winners and the non-investors. Results suggest that this assumption holds. More specifically, the winners report the highest and the losers the lowest satisfaction, with the non-investors in between (see online Supplementary Data).

[7] The two extreme cases are trivial: If $k = 0$, there is no competition at all; 'no investment' is the dominant strategy. If $k = N$, every investor wins per definition and, again, there is no competition.

[8] For a more detailed illustration of how to derive p^*, see online Supplementary Material.

[9] It should be noted that we do not claim that an increase in relative deprivation necessarily leads to a revolution. Rather, the model highlights one mechanism that only together with other factors is sufficient to trigger an uprising (Brush 1996, Coleman 1990: 472-479).

[10] A more detailed description of the experimental design and procedures, including instructions, can be found in the online Supplementary Data.

[11] See also endnote 4.

[12] The Gini coefficient is defined as:

$$\frac{1}{2\bar{x}} \cdot \frac{1}{N^2} \sum_{i=1}^{N} \sum_{j=1}^{N} d_{ij},$$

where d_{ij} is the absolute value of the difference between person i and j. The Gini is 0 when all payoffs are equal and approximates 1 with increasing inequality. A meaningful interpretation of the Gini coefficient requires a ratio scale with a meaningful zero value as with monetary payoffs.

[13] See Table A2 in the appendix and OSD for further details of our analyses of Gini coefficients and the variance.

[14] Here we report results from the high stake condition only. In the low stake condition, the decrease in the variance from the high to the low stake condition was more pronounced (p = .102). Note that splitting the sample into a high and a low stake condition implies a decrease in statistical power.

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Appendix

Table A1: Probability of investing and losing, respectively

	Experiment 1		Experiment 2		Experiment 3	
	(1a) *Invest*	(1b) *Lose*	(2a) *Invest*	(2b) *Lose*	(3a) *Invest*	(3b) *Lose*
1 position	-.188**	-.021	Ref.	Ref.	Ref.	Ref.
	(-2.76)	(-.32)				
2 positions	Ref.	Ref.	.300**	.133	.200**	.033
			(3.05)	(1.29)	(2.41)	(.34)
5 positions	.354***	-.125*	–	–	–	–
	(5.76)	(-2.24)				
N_{groups}	12	12	10	10	10	10
$N_{individuals}$	72	72	60	60	60	60
$N_{decisions}$	432	432	60	60	60	60
R^2	.18	.03	.08	.02	.12	.08

Notes: Discrete change effects derived from logit models. Cluster-robust standard errors. *z* statistics in parentheses. Controlled for session (not shown). * $p < .05$, ** $p < .01$, *** $p < .001$.

Table A2: Gini coefficients, variances and results from statistical tests

Experiment	*k*	*G or V*	*S.E.*	*Difference*	*Result*
1	1	V=9.18	.070	$k = 1 - k = 2$	z = –2.25, p = .024
	2	V=13.05			
	5	V=11.44	.078	$k = 5 - k = 2$	z= –0.53, p = .593
2	1	G=.106	.010	k=1 – k = 2	$t_{(df=8)} = -3.19$, p = .006
	2	G=.114	.003		
3	1	G=.128	.014	$k = 1 - k = 2$	$t_{(df=8)} = -2.30$, p = .025
	2	G=.161	.003		

Notes: *G*: Gini coefficient. *V*: Variance. Experiment 1: Cluster-robust *S.E.* obtained by interval regression with parametric variance. Experiments 2 and 3: Unpaired *t*-tests.