The Dynamic Interplay of Inequality and Trust - An Experimental Study*

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Abstract

We study the interplay of inequality and trust in a dynamic growth game, in which trust increases efficiency and thus allows higher growth of the laboratory economy in the future. We find that trust (as measured by the percentage of wealth invested in a trust game) is initially high in a treatment starting with equal endowments, but decreases over time. In a treatment with unequal endowments, trust is initially lower yet more robust. The disparity of wealth distributions across economies mitigates over time. Our findings suggest that both the level and the (exogenous or endogenous) source of inequality matters for the dynamics of trust.

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JEL Classification: C92, D31

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1 Introduction

There is a large body of empirical and theoretical economic literature on the relationship between inequality and the level of growth and prosperity in a country. The majority of empirical studies finds a negative link between income disparity and growth.[1] Some authors have argued that trust might be a key factor driving the relationship: Inequality decreases the level of trust and trustworthiness in an economy (e.g. because of larger social distance), which in turn negatively affects growth.[2] Empirical evidence is presented by Knack and Keefer (1997) and Zak and Knack (2001), who find that countries with higher income dispersion exhibit significantly lower values for a trust measure derived from survey data. Similarly, Alesina and Ferrara (2002) observe a negative connection between social distance and trust in the United States, and Gustavsson and Jordahl (2008) combine Swedish individual panel data with aggregate data on inequality to find that stronger disparities among people in the bottom half of the income distribution hampers trust. Complementarily, a number of empirical studies established a positive impact of trust on economic development (Knack and Keefer, 1997; La Porta et al., 1997; Zak and Knack, 2001).

However, Durlauf (2002), among others, notes that there are various problems of causality and identification in many of the empirical and survey studies that make it difficult to unambiguously establish a relationship between social capital, trust and economic indices. For instance, wealth

[1]Bénabou (1996), Ros (2000) and Glaeser (2005) survey the differing strains of literature. Some studies find competing evidence (e.g. Barro, 2000; Castelló-Climent, 2004; Forbes, 2000). Banerjee and Duflo (2003) argue that one reason for these differences might be a non-linear relationship: They observe that any *change* in inequality – in each direction – affects growth detrimentally. In a meta-analysis of empirical studies, De Dominicis et al. (2008) show that estimation techniques, included independents, development status of countries, and length of considered growth period have a significant impact on the estimated size and direction of the effect of inequality on growth.

[2]See Jordahl (2008) for an overview of different mechanisms explaining the negative impact of inequality on trust. Other authors see different forms of human capital, such as education (e.g. Castelló-Climent, 2004), or social preferences, as possible links. Corneo and Grüner (2000) and Corneo and Jeanne (2001) discuss concerns for social status, as these might discourage both poor and rich subjects to accumulate income in an unequal society and lower the political will for redistribution.

differences between economic agents may create larger social distance and thus hampering trust,[3] but may also reveal valuable information about past behavior, thereby making trust more or less risky. In this paper, we thus supplement the literature with a laboratory experiment that systematically investigates the dynamic interplay of trust, efficiency and distribution in a highly controlled setting.

The workhorse of our experiment is a growth game, which embeds a variant of the trust game introduced by Berg et al. (1995) into a dynamic context. In this game, an investor can send an amount of money to an anonymous trustee. Before the amount sent is received by the trustee, it is multiplied by a factor greater than one, and thus yields efficiency gains. Subsequently, the trustee decides on how much of the amount received she wishes to send back to the investor. The amount sent can be interpreted as a measure of trust, while the amount returned measures the degree of trustworthiness.[4]

However, in our growth game, income from interactions is cumulated over time. Participants start with either an unequal or equal distribution of initial endowments within a group. In each of several rounds they play the trust game with a randomly matched anonymous partner. Before making decisions, both transaction partners are informed about the current wealth of their opponent. Round payoffs are added to endowments, and therefore determine the amount that can be exchanged in future rounds. That is, investments and repayments (i.e. trust and trustworthiness) jointly affect the current and potential future growth rates of the 'laboratory economy', as well as the evolution of economic inequality.[5]

We observe that average initial investment levels are lower in the treatment starting with unequal endowments (IEQ) compared to the treatment

[3] See Glaeser et al. (2000), Fershtman and Gneezy (2001) and Haile et al. (2008a), among others.

[4] Berg et al. (1995)'s original game is sometimes called 'investment game', and the amount sent is interpreted as a measure for investment in risky projects subject to moral hazard. In our setting, that interpretation fits as well.

[5] E.g., if all investments yield the same positive rate of return, the dynamic game allows initially rich subjects to increase their endowments much more than initially poor subjects.

with equal endowments (EQ). However, 'relative trust', i.e. the share of accumulated wealth sent in a particular transaction, decreases over time in EQ, while remaining stable in IEQ. [6] Moreover, the disparity of wealth distributions across economies mitigates over time. Our analysis of individual behavior indicates that part of the reason for these aggregate effects is that trust is triggered differently across treatments: while wealth comparisons significantly affect trust in EQ, this is not the case in IEQ, suggesting that the (exogenous or endogenous) source and the dynamics of inequality play a major role for trust to emerge.

There is related experimental work. Sadrieh and Verbon (2006) conduct a public good game in which they implement different degrees of inequality between the participants and find no systematic effect of inequality on cooperation and efficiency level. In a similar dilemma game, Haile et al. (2008b) show that when a dictator can decide on the distribution of initial endowments, this choice has a decisive impact on subsequent behavior in the public good game. In particular, high inequality leads to decreased cooperation of the other participants. In our study of a dynamic trust game, we support the latter finding in that we initially observe a negative impact of inequality on efficiency, and at the same time complement this work by emphasizing that the source of inequality matters and that its disadvantage may be mitigated over time.[7]

The role of inequality in trust games has been studied by Brülhart and Usunier (2010) and Anderson et al. (2006). Both studies investigate static two person games. The former find no effect. The latter, employing equal as well as unequal distributions of show-up fees, being either private or

[6] Correspondingly, the sum of absolute investments stagnates in EQ and increases in IEQ.

[7] Other, more distantly related (and mixed) evidence comes from standard public goods games. In a survey on repeated public goods games with complete information, Ledyard (1995) concludes that economic heterogeneity among subjects generally lowers cooperation levels. Chan et al. (1996) find that poor subjects contribute more to a public good than rich subjects. Buckley and Croson (2006) conduct a linear public good game with heterogeneous endowments of participants. In their study, rich and poor subjects contribute on average the same absolute amount to a public good. Thus, poor subjects contribute a higher share of their respective endowments, and economic inequality increases within the experimental groups.

public information, observe only small and non-systematic effects of unequal endowments on trusting behavior. In our endogenously growing laboratory economies, we find that the source and dynamics of inequality systematically and significantly affect trust.

Section 2 explains the details of our experimental design and procedures, and sketches hypotheses based on previous empirical results and behavioral models. Our experimental data and statistical analysis are presented in Section 3. We discuss our results and conclude in Section 4.

2 Experiment design and hypotheses

Experiment Design. In our study we focus on the dynamic interaction of trust, trustworthiness and inequality. Therefore, we develop a growth game which embeds the essentials of Berg et al. (1995)'s trust game, but puts them into a dynamic growth and distribution context. The growth game is played over 20 rounds. In each round, two randomly and anonymously matched subjects play a variant of the trust game. One of the subjects is randomly assigned the role of the investor, the other the role of a trustee. Before decisions are made, each subject is informed about his own and the opponent's wealth in the current round. Wealth is defined as the initial endowment plus any payoffs that have been accumulated in earlier rounds. A player's wealth limits the amounts that he can invest or return in the current round of the growth game in the following way. The investor decides on an amount S, which is not allowed to exceed his current wealth, to be sent to the trustee. Any amount sent is multiplied by the factor 1.2, i.e. the trustee receives $1.2S$. Next, the trustee can decide on the amount R to be sent back to the investor. The minimum amount to be returned is $0.9S$, or 90% of the amount sent. Observe that the *one-round* interaction in our game is equivalent to the original trust game interaction with a sent amount multiplier of three (just like in the original trust game by Berg et al., 1995), with the exception that the amount that can be sent is restricted to 10% of the investor's wealth. The restriction was implemented to limit the maximum benefits from trust and trustworthiness that can be accumulated over rounds. With our restriction, our experimental economies can still grow by an expected factor of up to 6.72.[8]

We varied the distribution of the initial endowments across our two treatments. In the equality condition (EQ), all subjects were endowed with an amount of 500 ET (Experiment Talers) before the first round. In the inequality treatment (IEQ), half of the subjects in each matching group received 200 ET, and the other half received 800 ET. In order to investigate experience effects and to test robustness of behavior, we played two runs of 20 rounds; that is, after the first 20 rounds of the experiment we restarted the game for another 20 rounds. Subjects were told before the session that the experiment consisted of several runs, one of which would be randomly selected for payoff.

The experimental sessions took place in the Cologne Laboratory for Economic Research. We conducted four sessions, two for each of our treatments. Subjects were recruited using the Online Recruitment System by Greiner (2004). Altogether 128 student subjects participated. Each session consisted of 32 participants. Random matching per round, subject to the constraint that two subjects would never interact with each other in consecutive rounds, was restricted to groups of 8 participants.[9] Due to this procedure, we obtained observations on 8 statistically independent 'economies' for each treatment. Overall, we collected 2,560 choices for each player role.

The experiment was computerized using the zTree software (Fischbacher, 2007). After subjects arrived and were randomly assigned to a cubicle, instructions were distributed.[10] Questions were answered privately. At the

[8]As in each round only half of the subjects in the economy are randomly assigned to the role of the investor, the economy can grow by an expected factor of 1.1 per period with full investment, yielding an expected maximum growth rate over 20 rounds of $1.1^{20} = 6.72$. If we had used the original efficiency factor of 3 from Berg et al. (1995)'s trust game instead of 1.2, the expected maximum growth rate over 20 rounds in our game would be equal to 2^{20}. We also note that trust behavior appears rather robust against changes in monetary stakes; see, for example, Buchan and Croson (2004), Sutter and Kocher (2007), and, for an exception, Holm and Nystedt (2008).

[9]Subjects were informed about the random rematching procedure, but not that it was restricted to groups of eight, conveying the impression that being matched with the same opponent more than once is very unlikely.

[10]Instructions are included in the Appendix.

end of the experiment subjects filled in a post-experimental questionnaire. Finally, either Run 1 or Run 2 was selected for payoff by publicly rolling a die. Participants were paid out privately and left the laboratory. The exchange rate was fixed at 150 ET = 1 Euro. The average payoff was 12.25 Euros (including a show-up fee of 2.50 Euros) with a standard deviation of 5.09 Euros. Each session lasted approximately one and a half hours.

Hypotheses. In the remainder of this section we will motivate a number of competing hypotheses for the dynamic interplay of inequality and trust in our experimental setup. These hypotheses help organizing our analyses and results. At the same time, however, we wish to caution that our experiment is mainly designed to complement the empirical studies, and not as a test of any particular theory - if only because there is no theory yet that addresses the potentially complex dynamics we are interested in.

The standard game theoretic prediction is straightforward. Independent of the initial distribution of wealth, because of the finiteness of the growth game, there is no trust and no trustworthiness among selfish and rational players if selfishness and rationality are common knowledge.

However, starting with Berg et al. (1995), numerous experiments have shown that subjects are willing to invest and return non-trivial amounts of money in the trust game. For a survey of the trust game literature see, for example, Camerer (2003). While the experimental one-shot version of the trust game is by now well-analyzed and -understood, the dynamic interplay of inequality and trust in the context of our growth game is not easily predicted. However, observe that both of our treatments start with identical *average* endowments. If inequality does not affect subjects' willingness to send and return money, relative to their endowments, the two treatments may be expected to yield equivalent results with respect to growth rates (Null Hypothesis).[11] On the other hand, the empirical and experimental literature on social and economic heterogeneity cited in Section 1 suggests that

[11] In the beginning of the first round, the average endowment of investors in treatment EQ is equal to 500, as it is in treatment IEQ. Thus, if the same share is sent and returned, expected overall invested amounts are the same, as well as the amounts returned. Therefore, the expected endowments of investors in round 2 are the same in both treatments. The same reasoning applies to all consecutive rounds of the game.

we may observe a negative impact of inequality on trust and trustworthiness in our setting. Dispersion of wealth could increase social distance between economic agents and, as a result, trust and trustworthiness may decrease. To the extent our experiment captures some of the underlying mechanisms assumed in this literature, we should expect less growth and lower efficiency in treatment IEQ (Hypothesis 1).

Additionally we note that theories of outcome-based social preferences can organize some of the deviations from standard equilibrium behavior observed in the trust game. For instance, inequity aversion models (Bolton and Ockenfels, 2000; Fehr and Schmidt, 1999) can in principle explain both trust and trustworthiness in the trust game.[12] However, these models do not yield unambiguous comparative static predictions across the two treatments of our growth game. To see why, observe for instance that a rather fair-minded investor who is matched with a relatively poor trustee may send money to equalize payoffs, while a rather selfish investor may not send money because he cannot expect to get anything back from a relatively poor opponent. Thus, the predictions of inequity aversion models will depend on the distribution of preferences.[13] It appears, though, that 'myopic', straightforward concerns for equal payoffs lead to more trust and trustworthiness in IEQ (Hypothesis 2) in the following sense: Even when an inequality-averse subject assumes that everybody else behaves in a completely selfish manner, he still has reason to trust and to be trustworthy towards relatively poor opponents in the inequality treatment (where, in the beginning of round 1, the payoff distribution is unfair), but no such incentive exists in the equality treatment (where the payoff distribution is fair if everybody behaves selfishly).

[12] See Bolton and Ockenfels (2000), page 187, for a detailed description of the mechanics of the fairness models in the context of Berg et al. (1995)'s trust game.

[13] A related social preferences approach deals with positional concerns (as analyzed, e.g., by Frank, 1985). For instance, Solnick and Hemenway (1998) and Pingle and Mitchell (2002) report on survey evidence for positional concerns over income. While Li and Pingle (2007), Clark et al. (2010) and Ockenfels et al. (2010), for example, provide laboratory and field evidence that relative position has an impact on behavior, positional concerns alone cannot provide an explanation for why people invest and send back money in the trust game.

These hypotheses do not take into account the dynamic features of our game. For instance, wealth in the growth game may reflect the interaction history of participants and so may reveal decision-relevant information. More specifically, in treatment EQ, where all participants start with equal endowments, the wealth of a transaction partner might allow conclusions about the degree of selfish behavior in the past. In treatment IEQ this signal is blurred by the initial wealth differences. Thus, we hypothesize that wealth information affects trust in EQ but not in IEQ (Hypothesis 3). As we will show in the next section, we do not find support for Hypotheses 1 and 2. Hypothesis 3, on the other hand, is supported by the data, with significant implications for overall levels of trust and trustworthiness.

3 Experimental Results

3.1 Aggregate Data

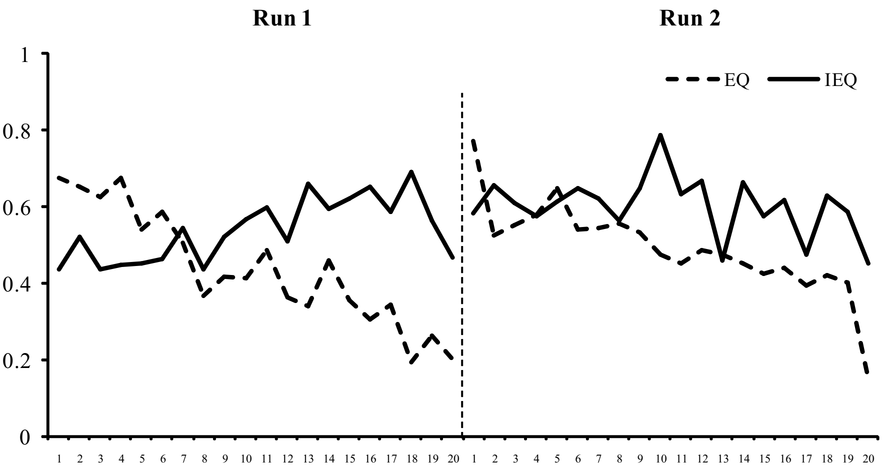
Efficiency. Figure 1 depicts the evolution of average send rates over time. We define the send rate in a particular round as the share of investors' wealth in this round that they invest in transactions. For figures and non-parametrical tests the send rate averages are calculated by adding up all amounts sent in a matching group, and dividing the sum by the total wealth of the senders.[14]

Figure 1 shows that the dynamics of trust differ markedly between the treatments. In the first round of the games, the equal distribution of wealth leads to higher trust levels than the unequal distribution, although applying two-sided Mann-Whitney-U (MWU) tests to respective matching group data in round 1 does not yield statistical significance.[15] However, send rates in treatment EQ strongly and steadily decrease over time from 68% in round 1 to 20% in round 20 in Run 1, and from 77% to 15% in Run 2, while send rates in IEQ increase slightly in Run 1 and decrease slightly in Run 2.

[14] Our focus is on aggregate behavior and independent observations. However, our conclusions from statistical tests would not be different if we had used averages over individual send rates.

[15] All conclusions in the remainder of the paper are identical if we use two-sided robust rank-order tests instead of Mann-Whitney-U tests.

FIGURE 1
Average Send Rates over Rounds



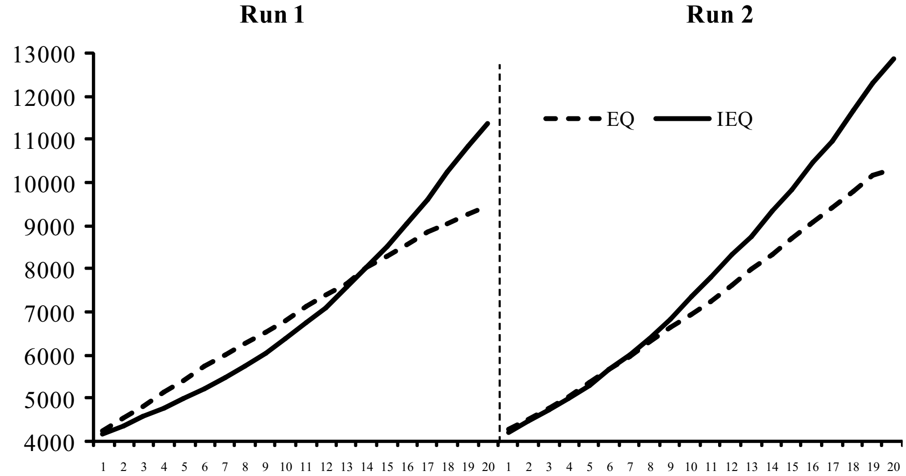
Correspondingly, in EQ average send rates of the matching groups are significantly and negatively correlated with the number of rounds (Spearman-ρ = -0.575, $p < 0.001$ and Spearman-ρ= -0.389, $p < 0.001$ for Run 1 and 2, respectively) while this is not (strongly) so in IEQ (Spearman-ρ= 0.081, $p = 0.309$ and Spearman-ρ= -0.173, $p = 0.029$ for Run 1 and 2, respectively).[16] Correspondingly, absolute amounts sent remain roughly constant in treatment EQ while increasing in treatment IEQ.[17]

As more investment directly expands overall wealth, because the latter is a cumulative measure of the former, the different dynamics in trust across laboratory economies are reflected in different growth rates of overall wealth. Figure 2 depicts average economy wealth over time. There are substantial efficiency gains in both treatments and runs, with total average wealth more than doubling in all runs of both treatments. Initially, wealth in treatment

[16] Applying two-sided Wilcoxon Matched Pairs Signed Ranks tests, a similar conclusion is reached when comparing matching group averages in the first and the second half of each run.

[17] Spearman-ρ-values for the correlation between average absolute amounts sent and the number of rounds yield $\rho = -0.127$, $p = 0.109$ (Run 1) and $\rho = 0.095$, $p = 0.232$ (Run 2) for treatment EQ and $\rho = 0.457$, $p < 0.001$ (Run 1) and $\rho = 0.328$, $p < 0.001$ (Run 2) for treatment IEQ.

FIGURE 2
Average Total Economy Wealth over Rounds, in ET



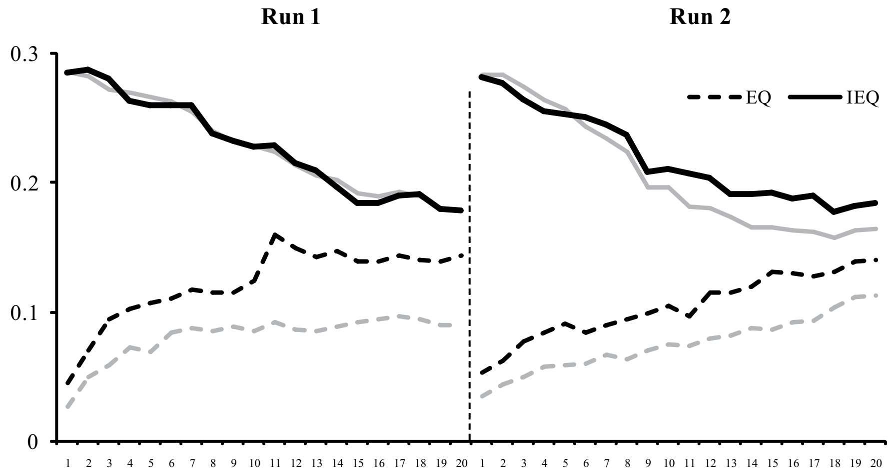
IEQ lags behind. However, as average send rates remain on a relatively high level in treatment IEQ and significantly decrease in treatment EQ, the lag is eventually counterbalanced and reversed in the last few rounds. Statistically, the wealth of IEQ economies in rounds 1 to 5 is weakly significantly lower than in EQ ($p = 0.065$, two-sided MWU test), while final wealth levels are not significantly different from each other. In Run 2 we do not observe large initial differences, and after the first few rounds treatment EQ lags behind.[18] All in all, with respect to send rates and accumulated wealth levels, we find little evidence for Hypothesis 1 about lower trust and efficiency in a treatment with unequal initial wealth distribution.

Distribution. We use Gini coefficients to analyze the dispersion of in-

[18] To capture growth dynamics in our game, we calculate regression models for each experimental run with the average amount sent per treatment and round as the dependent variable (not reported here). As explanatory variables, we include the number of rounds, the squared number of rounds and the interaction of both variables with a dummy for the IEQ treatment. For both runs, the models imply a small and declining growth of investments in EQ that turns negative in the course of the game. For the IEQ treatment, the models predict an increasing time trend for investments in Run 1 and a decreasing time trend in Run 2 that, however, is associated with larger amounts sent than in treatment EQ.

FIGURE 3

Observed and Simulated Gini Coefficients over Rounds



Note: Black lines refer to observed, grey lines to simulated values.

dividual wealth levels.[19] Figure 3 shows average matching group Gini coefficients in treatments EQ and IEQ (black lines). We observe that Gini coefficients strongly and significantly decrease (increase) in treatment IEQ (EQ).[20] Furthermore, the values for the Gini coefficients tend to converge to each other towards the end of a run. In the last round of a run, IEQ and EQ Ginis are not significantly different (MWU, $p > 0.1$ for both runs).

One of the reasons why the differences in wealth dispersion are mitigated over time is that average return rates (which are generally around the break-even level that makes an investment profitable, not much unlike in Berg et al.'s study) tend to be higher in IEQ than in EQ, leading to more balanced marginal payoffs after each transaction in IEQ.[21] In the aggregate data, we

[19] The Gini coefficient as a measure for disparity takes the value of zero if the income is equally distributed among the subjects and $(n-1)/n$ if all wealth is concentrated on only one subject. Here, the maximum value of the Gini coefficient is 7/8, as the number of subjects per experimental matching group is $n = 8$.

[20] Two-sided Wilcoxon Matched Pairs Signed Ranks tests applied to matching group averages for rounds 1-10 and rounds 11-20 of each run yield $p = 0.008$ for treatment IEQ (both runs) and $p = 0.055$ and $p = 0.008$ for treatment EQ (Run 1 and Run 2, respectively).

[21] We define the return rate as the amount returned minus the mandatory 90% ($R - 0.9S$),

find that, in the first run, average return rates are 24% lower in treatment EQ than in treatment IEQ (two-sided MWU-test, $p = 0.021$) - yet the effect decreases and becomes statistically insignificant in Run 2. Overall, differences in return rates across treatments and over time are less pronounced than differences in send rates.

There are potentially two different sources of redistribution in our setting: on the one hand, it may be that rates are not conditioned on individual wealth states or wealth comparisons. Because, for a given rate, richer subjects send more in absolute terms than poorer subjects, such unconditional behavior moves the economy towards more equality when starting with unequal endowments. On the other hand, redistribution can be the result of send and return rates which systematically depend on own and others' wealth in the current state. Depending on the nature of conditional behavior (which will be analyzed in subsection 3.2) and the heterogeneity of the behavioral patterns, the resulting system behavior may increase or decrease equality relative to what can be expected from unconditional interaction.

In order to isolate the effects of these two potential explanations, we simulate Gini coefficients for unconditional, homogenous behavior. More specifically, simulations are based on the same role and group matchings as implemented in our experiment. Additionally, we assume that in every round all participants in a matching group behave identical – like the observed group average.[22] If actual behavior is unconditional with respect to wealth levels and differences, simulations and actual behavior should not differ.

The average simulated Gini coefficients (see the grey lines in Figure 3) follow the same general pattern as the observed ones. In treatment IEQ, simulated and observed Gini curves are nearly the same (Run 1) or differ only slightly (Run 2). Consequently, Wilcoxon Matched Pairs Signed Ranks (WMPSR) tests yield no significance comparing average observed and simulated Ginis for whole runs or 10 round intervals. In treatment EQ, observed

divided by the amount received minus the mandatory 90% ($1.2S - 0.9S$). For example, a return rate of 1/3 implies that the trustee returns exactly the amount invested by the investor.

[22]This procedure yields the same economy growth rates in the simulation as in the experiment.

Gini values are constantly higher than the simulated values, and the differences are significant at $p < 0.016$ with two-sided WMPSR tests applied to whole runs or 10-round intervals.

Summing up, on the aggregate level, we find little evidence for systematic and deliberate redistributive behavior from rich to poor in treatment IEQ. On the contrary, inequality rises faster than expected under the assumption of unconditional trust and trustworthiness in EQ, suggesting that wealth distribution systematically affects trust and trustworthiness in this treatment.

3.2 Individual Decisions

To investigate if wealth levels of senders and responders have a distinct impact on trust and trustworthiness, we regress individual send and return rates on a number of independent variables.[23] Our focus is on relative wealth standings of senders (W_S) and responders (W_R) in each treatment that are derived dividing the respective decision maker's wealth by the average wealth in her economy (matching group). For sender and responder decisions, we calculate linear models with random effects to account for unobservable heterogeneity of the experimental subjects. The estimated regression models are displayed in Tables 1 and 2.

With respect to sender decisions, we start our analysis with the following specification: Besides the round number (1-20), and two dummies for treatment (0 for EQ, 1 for IEQ) and run (0 for 1st, 1 for 2nd run), we include the relative wealth standing of the sender (W_S) and the responder (W_R) prior to the current transaction. In order to capture a possible dependency between the wealth variables, we also include the interaction term $W_S \times W_R$.

[23] We had to exclude 10 and 314 observations in the models on the send rate and return rate, respectively, because the send rate is only defined for positive wealth of the investor, and the return rate is only defined for positive amounts sent. The reason for the 10 observations with a sender wealth of zero was that a participant erroneously returned his entire round wealth in one interaction. We also note that, in our post-experimental questionnaire, we collected demographic data on age, gender and field of studies of our participants. When we include these variables in our regression models, we do not find consistent effects on sender and responder behavior, while all our previous results remain identical.

TABLE 1

Random effects regressions of individual send rates

Dependent Variable	Model 1 Send rate Coeff	 StdErr	Model 2 Send rate Coeff	 StdErr	Model 3 Amount sent Coeff	 StdErr
Constant	1.872***	[0.164]	1.847***	[0.169]	1,145.5***	[192.8]
Treatment	-1.164***	[0.178]	-1.254***	[0.184]	-1,113.9***	[208.1]
W_S	-1.008***	[0.155]	-1.106***	[0.163]	-710.0***	[182.1]
W_R	-1.004***	[0.148]	-0.990***	[0.152]	-959.8***	[174.1]
$W_S \times W_R$	0.727***	[0.145]	0.714***	[0.151]	710.7***	[170.2]
Treatment$\times W_S$	0.962***	[0.163]	1.062***	[0.173]	1,006.3***	[191.7]
Treatment$\times W_R$	0.946***	[0.154]	0.952***	[0.159]	852.1***	[180.8]
Treatment$\times W_S \times W_R$	-0.670***	[0.149]	-0.688***	[0.157]	-609.0***	[175.7]
Round	-0.011***	[0.001]	-0.012***	[0.001]	14.6***	[1.1]
Run	0.035***	[0.011]	0.012	[0.012]	72.3***	[13.0]
Experience			0.534***	[0.061]		
Experience×Treatment			-0.070	[0.084]		
Observations	2550		2186		2550	
Wald-Chi	255.5		381.8		348.0	

Standard errors are given in brackets. *, **, and *** indicate significance at the 10%, 5%, and 1%-level, respectively. Random effects are calculated on the level of experimental subjects.

Specification 1 shows that wealth positions influence trusting behavior in treatment EQ, but are of only minor importance in treatment IEQ. In treatment EQ, the effect of both direct wealth variables is negative. That is, participants send proportionally less the richer they are and the richer the responder is.[24]

On the contrary, wealth effects are largely mitigated in treatment IEQ (see the interaction effects of Treatment with W_S and W_R). These observa-

[24]The positive and significant interaction term $W_S \times W_R$ mitigates the direct effect of relative wealth positions somewhat, but does not change the net effect (see also the illustration of the effects in Figure 4).

tions are consistent with the simulation results of the Gini coefficient dynamics. While the trust decisions in EQ systematically affect the wealth distribution in the economy beyond what can be expected from non-conditional, homogenous trust patterns, this is not the case in IEQ.

The effect of the repetition of the game (Run) is positive and corresponds to an increase of average send rates in the second run of the game, across treatments. With respect to the evolution of investments over time, we find a negative effect of the number of rounds. Finally, the coefficient of the treatment dummy is significant suggesting a negative effect of initial inequality. However, when taking into account the interaction with wealth variables, this effect is largely counterbalanced.[25]

Our main result - the conditioning of trust on sender and responder wealth - is robust against inclusion of a 'personal experience' variable (Model 2). Here we use the same specification as in Model 1, but also include the average return rate a sender experienced in previous rounds (variable: Experience).[26] The coefficient is highly significant and has the expected positive sign: the higher a sender's average return rate has been in previous rounds, the more is she willing to invest in a given round.[27] Still, the reported effect of the wealth level variables remains highly significant.

To account for the accumulation of absolute wealth in the course of the game, we calculate Model 3 with the same set of explanatory variables as in Model 1, using the absolute amount sent in a transaction as the dependent variable. Results correspond to our previous results: Senders invest less in absolute terms the richer they are and the richer their transaction partner is, and again, the effect is mitigated by the positive and significant interaction term $W_S \times W_R$. As for the relative measure, in treatment IEQ, however,

[25]The conclusions are the same if we include an alternative variable for the wealth differences, namely $W_{DIFF} = W_S - W_R$ instead of W_R. Whereas the coefficient of W_S remains negative and significant for treatment EQ in this specification, W_{DIFF} has a positive impact on the estimated send rate. This implies that predicted send rates decrease with a lower relative position of the sender.

[26]The model is calculated only for observations where subjects acted in the role of the sender at least once before and transferred positive amounts.

[27]Engle-Warnick and Slonim (2004, 2006) also find that subjects in repeated trust games condition their behavior on past outcomes.

these effects are counterbalanced, with the effect of the sender wealth W_S even turning positive in absolute terms: relatively rich subjects send higher absolute amounts than relatively poor subjects. Finally, the number of rounds and the Run dummy have positive and significant signs in Model 3, indicating that accumulated wealth is reinvested into trust transactions in later rounds of the game and that investments tend to be higher in the second run.

TABLE 2
Random effects regressions of individual return rates

	Model 1		Model 2		Model 3	
Dependent Variable	Return rate		Return rate		Amount returned	
	Coeff	StdErr	Coeff	StdErr	Coeff	StdErr
Constant	0.603***	[0.164]	0.602***	[0.166]	84.5***	[29.7]
Treatment	-0.167	[0.171]	-0.278	[0.175]	-56.4*	[31.4]
W_R	-0.260*	[0.153]	-0.309**	[0.156]	-57.0**	[28.2]
W_S	-0.484***	[0.155]	-0.494***	[0.157]	-71.9**	[28.4]
$W_R \times W_S$	0.371**	[0.149]	0.384**	[0.154]	50.2*	[27.5]
Treatment$\times W_R$	0.212	[0.160]	0.272*	[0.165]	50.3*	[29.5]
Treatment$\times W_S$	0.327**	[0.159]	0.356**	[0.162]	61.7**	[29.4]
Treatment$\times W_S \times W_R$	-0.298*	[0.153]	-0.316**	[0.159]	-44.9	[28.3]
Send rate	0.152***	[0.016]	0.155***	[0.016]		
Round	-0.005***	[0.001]	-0.005***	[0.001]	-0.4**	[0.2]
Run	-0.001	[0.011]	-0.011	[0.012]	-3.1	[2.0]
Experience			0.191***	[0.061]		
Experience$\times$Treatment			0.064	[0.080]		
Amount sent					0.1***	[0.0]
Observations	2246		1922		2246	
Wald-Chi	257.0		266.7		1594.0	

Standard errors are given in brackets. *, **, and *** indicate significance at the 10%, 5%, and 1%-level, respectively. Random effects are calculated on the level of experimental subjects.

For the regressions of the return rate (see Table 2), we start with the same set of variables as Model 1 for the sender, but also include the send rate of the counterpart. Firstly, we observe that in the EQ treatment rich senders earn less from their trusting decisions than poor senders. The coefficient of W_S is negative and highly significant. The coefficient of responder wealth W_R is also negative, but only marginally significant, and the positive interaction term $W_R \times W_S$ countervails this effect. As for send rates, predicted wealth effects are largely offset in treatment IEQ.

Furthermore, participants reciprocate high investments, as the share returned is positively associated with the send rate. With respect to time variables, we find a negative effect of the number of rounds while the Run 2 dummy is insignificant.[28]

In Model 2, we additionally include the Experience variable, i.e., a responder's average return rate from trusting decisions in previous rounds.[29] Its positive and significant coefficient shows that responders who have experienced higher return rates in the role of senders are more likely to honor a trusting decision, which suggests a pattern of indirect reciprocity. Again, this specification does not change our results concerning relative wealth positions.

Model 3 is a specification with the absolute amount returned voluntarily as the dependent variable, i.e., the amount that exceeds the guaranteed 90% of the investment. We include the same set of explanatory variables as in Model 1 except for the send rate that is replaced by the absolute amount sent. It turns out that - as for relative and absolute amounts sent - the results correspond to the models with relative return rates: wealth levels W_R and W_S have a negative and significant impact in treatment EQ, whereas relative positions have little impact on absolute amounts returned by the responder in treatment IEQ.

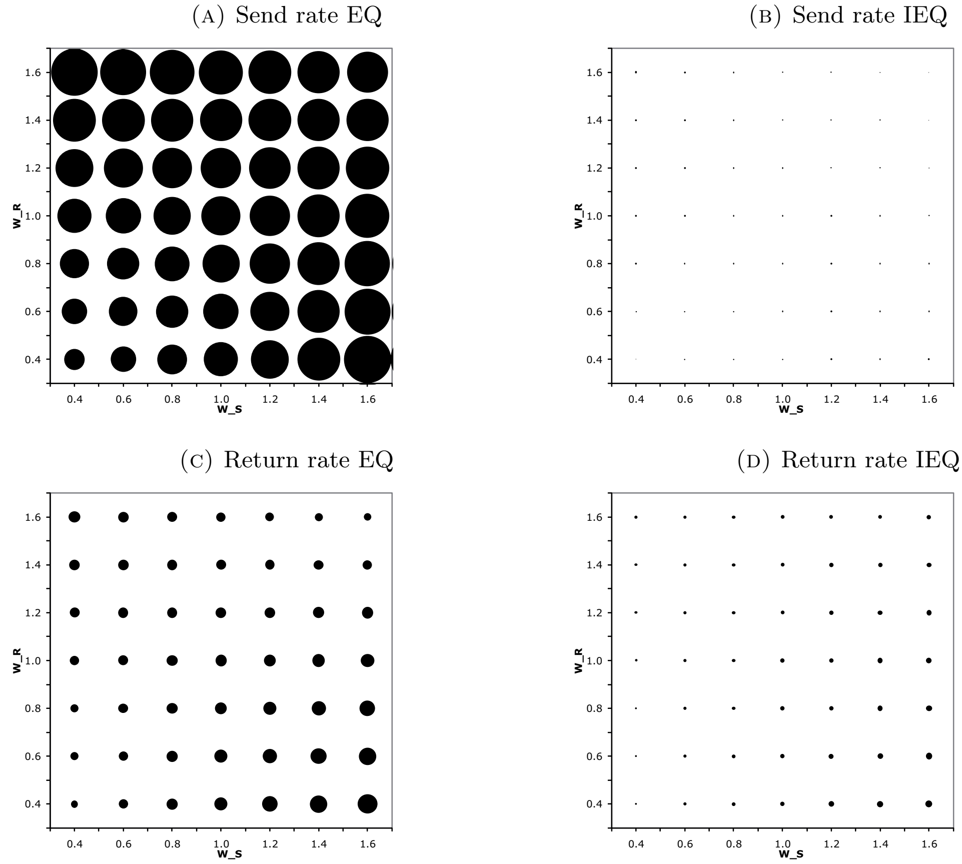
To visualize the results from the regression models, Figure 4 plots the

[28] As in the case of send rates, conclusions remain similar if we include W_{DIFF} instead of W_R.

[29] Similar to Model 2 for send rates, we include only observations for subjects who made at least one decision as a sender and transferred positive amounts.

FIGURE 4

Overall effects of relative wealth of sender and responder on send rate and return rate (inverse)



Note: Bubble sizes represent the relative size of the inverse joint effect of relative wealth of sender and responder before the trust decision (i.e., a larger bubble indicates a more negative overall effect on send or return rate). Effects were calculated using the estimated regression coefficients in Model 1 in Table 1 and Model 1 in Table 2 for relative responder and sender wealth $W_S, W_R \in \{0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6\}$. More than 90% (95%) of all observations in treatment IEQ (EQ) lie in this interval.

estimated inverse effect of relative wealth positions on send and return decisions, derived from Models 1 on send and return rates in Tables 1 and 2, respectively. The x-axis of each graph represents the relative wealth of the sender W_S, whereas the y-axis represents relative responder wealth W_R. Values on both axes vary between $W_S = W_R = 0.4$ and $W_S = W_R = 1.6$, as more than 90% (95%) of all observations in treatment EQ (IEQ) lie in this interval. The sizes of the bubbles display the estimated *inverse* effect on send rates and return rates for different relative positions of senders and responders in both treatments. A larger bubble represents a stronger negative effect on behavior and subsequently a lower send rate (return rate).

For example, part A of Figure 4 – estimated send rates in treatment EQ – shows that the largest negative effect on trust levels is expected among the most unequal transaction partners (the richest senders and the poorest responders and vice versa). With respect to return rates in treatment EQ (part C of Figure 4), the sizes of the estimated effects are somewhat smaller, yet wealth positions have a negative impact on return rates of relatively poor responders towards relatively rich senders. In treatment IEQ, on the other hand, relative wealth positions have virtually no relevance for send and return decisions.

To sum up, our analysis of individual behavior does not corroborate Hypothesis 2 about higher trust levels resulting from deliberate redistribution in treatment IEQ. However, it provides evidence for Hypothesis 3 that subjects condition their behavior on relative wealth positions in treatment EQ, but not in treatment IEQ.

4 Discussion and Conclusions

We analyze the behavioral dynamics of economic inequality and trust. In our laboratory economies, participants start with either equal or unequal endowments. They then repeatedly play an investment game and, by accumulating their payoffs, endogenously create growth and wealth distributions. In each round, both transaction partners are informed about the current wealth of their opponent.

Initially, investments tend to be higher both in absolute and relative terms in economies starting with equal endowments (EQ) compared to economies starting with unequal endowments (IEQ). However, relative trust levels in EQ significantly deteriorate over time, leading to stagnating investments, while stable trust rates in IEQ enable increasing investments. As a result, EQ economies initially grow faster, but are ultimately outperformed by the IEQ economies in terms of efficiency. Over time, IEQ economies become more equal, while EQ economies become more unequal, such that distributions of wealth are converging to each other over time.

The different dynamics of EQ and IEQ at the aggregate level are mirrored by the behavioral pattern at the individual level. Trust and trustworthiness in the EQ economies are conditioned on the investor's and the trustee's wealth, while these effects are largely counterbalanced in IEQ. Conditional trusting behavior appears to be the main reason for the downward trend in EQ.

These differences support our hypothesis that subjects condition their behavior on wealth levels because relative wealth has a different source and information value in EQ compared to IEQ economies. A large relative wealth in EQ is on average a rather reliable signal for not having been trustworthy in the past: ceteris paribus, unfair (non-reciprocal) agents become richer. A large relative wealth in IEQ, on the other hand, may not only be the result of relatively selfish behavior but also of the exogenously imposed unequal endowments. This reasoning is supported by the data, as we find consistently negative and significant correlations between half-run wealth and average return rates of a subject in the EQ treatment, but there is no such relation in the IEQ treatment.[30] Models of strategic behavior and social behavior are then in line with the observed patterns of (conditional) trust. Because a higher wealth tends to suggest lower trustworthiness in EQ (but not in IEQ), richer people should be trusted less in EQ (but not in IEQ). Additionally, a number of studies (see, for example, Bolton et al., 2005; Frey et al., 2004) suggest that people are more tolerant towards inequitable outcomes if inequality is the result of a procedurally fair allocation mechanism. Thus,

[30] Pearson correlation coefficients of average return rates and final wealth in half-runs of treatment EQ are $R = -0.358$, $p = 0.004$ and $R = -0.479$, $p < 0.001$ for rounds 1-10 and rounds 11-20 in Run 1, and $R = -0.397$, $p = 0.001$ and $R = -0.309$, $p = 0.013$ for rounds 1-10 and rounds 11-20 in Run 2, respectively. On the contrary, in treatment IEQ half-run correlations between average return rates and wealth are low or insignificant; $R = -0.142$, $p = 0.262$ and $R = -0.048$, $p = 0.704$ for rounds 1-10 and rounds 11-20 in Run 1, and $R = -0.240$, $p = 0.056$ and $R = -0.152$, $p = 0.231$ for rounds 1-10 and rounds 11-20 in Run 2, respectively.

to the extent that high wealth exogenously and randomly imposed in IEQ economies is deemed a fair outcome while high wealth endogenously resulting from selfish behavior is perceived as unfair, inequality in EQ may invoke a different social response than inequality in IEQ. Modeling the strategic and social roots of the dynamic interaction of distribution and efficiency is left to future research.

Our results suggest that the relationship between inequality and growth through the transmitter trust is not as linear and straightforward as suggested in the related empirical literature (reviewed in Section 1). Specifically, our results provide evidence that the source and dynamics of inequality within a society may systematically affect trust, prosperity and growth.

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Appendix

A Instructions

Below we include the instructions used in the first run of treatment IEQ, translated from German. Instructions for the other runs and treatments were worded analogously.

Welcome to this experiment! In this experiment you can earn money. How much money you earn depends on your decisions and the decisions of the other participants.
From now on, please do not communicate with other participants. If you have a question concerning the experiment, please raise your hand! We will come to your place and answer your question privately. If you do not comply with these rules, we will have to exclude you from the experiment and all payments.
In the experiment, we will use ET ("Experiment-Taler") as the currency. At the end of the experiment, your payoff will be converted into Euros and will be paid out in cash. The exchange rate is 150 ET = 1 Euro. In the experiment, all amounts in ET are rounded to whole numbers.
The experiment consists of several parts. The payoff of only one of these parts will be paid out at the end of the experiment. When the experiment is finished, a die will be used to determine which part will be used for payment. The following instructions refer to the first part of the experiment. After the first part is finished you will receive new instructions.
In this part all participants receive an initial endowment. Half of the participants receive an initial endowment of 800 ET, the other half receive an initial endowment of 200 ET. It will be determined by chance which participant receives which initial endowment.
This part consists of 20 rounds. In each round pairs are formed randomly, each pair consisting of participant A and participant B. It is guaranteed that you do not interact with the same participant in two consecutive rounds. The roles A and B within the pair are assigned randomly in every round.

The identity of the participant you are interacting with is secret, and no other participant will be informed about your identity. In this sense, your decisions are anonymous.
Every round proceeds as follows:

- At the beginning of the round both participants are informed about their roles (A or B), the current round (1-20), their own current wealth and the current wealth of the other participant.
- Then participant A decides how much of his/her wealth he/she wants to send to participant B.
- The amount sent by participant A is multiplied by 1.2. This means participant B not only receives the amount sent, but 120 % of the amount sent (1.2*amount sent).
- Then participant B decides how much he/she sends back to participant A. He/she must send back at least 90 % of the amount sent (0.9*amount sent). The upper limit for the amount sent back is the wealth of participant B.

After that the round is over. Wealth at the end of the round is calculated as follows:

- Participant A: Wealth at the end of the round = wealth at the beginning of the round - amount sent + amount sent back (at least 0.9*amount sent)
- Participant B: Wealth at the end of the round = wealth at the beginning of the round + 1.2*amount sent - amount sent back (at least 0.9*amount sent)

Wealth at the beginning of a new round is equal to wealth at the end of the preceding round. The payment for this part in case it is selected is given by the wealth at the end of the last round of this part.