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Heterogeneity, Inequity Aversion, and Group Performance

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Abstract

We investigate the effects of inequality in wealth on the incentives to contribute to a group output when agents are inequity averse and may differ in ability. We show that equality may lead to a reduction of contributions below levels generated by purely selfish agents. But introducing inequality motivates more productive agents to exert higher efforts and help the group to coordinate on equilibria with less free-riding. As a result, less able agents may benefit from initially disadvantageous inequality. Moreover, the more inequity averse the agents, the more inequality should be imposed even by an egalitarian social planner.

Keywords

Group performance; heterogeneity; inequality; inequity aversion; public goods

JEL Classification

D03; H41; D31; D63

1 Introduction

While most studies on collective action so far have focussed on situations in which agents with identical characteristics interact with each other, in social and economic life homogeneous-group environments are the exception rather than the rule. For instance, people often differ with respect to important attributes such as preferences, resources, wealth, ability, or motivation which can affect their willingness to participate in collective action. Besides that, while standard economic theory predicts that people are only interested in their own material outcomes, there is now a broad number of studies indicating that many people tend to dislike inequality. For instance, formal models of inequity aversion such as those by Fehr and Schmidt (1999) or Bolton and Ockenfels (2000) have been quite successful in explaining several patterns of behavior observed in laboratory experiments and

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in the field.[1] In this paper, we combine these two insights and investigate how heterogeneity and fairnes conerns interact in a social context. In particular, using a simple model we analyze how the interplay between two sources of heterogeneity - income and ability - affects the motivation of inequity averse agents to contribute to a joint group output such as a public good or a team outcome.[2]

Intuitively, inequity aversion should determine the willingness to accept inequality in payoffs which, in turn, should be an important factor affecting the incentives to contribute. While a straightforward conjecture would be that inequity aversion should lead to the optimality of a more egalitarian distribution of wealth, we show that in our heterogeneous setting this is no longer the case. More specifically, we show that income equality is only optimal if agents are of the same ability, but that is has detrimental effects for total contributions and welfare when agents differ in their abilities. Instead, in the latter case the distribution of initial income should be aligned to the difference in the agents' abilities favoring more able agents.

Of course, from a welfare perspective, it may not be surprising that agents who contributed more should get a higher income *ex-post* to generate equity. But our mechanism shows that it can be optimal to create inequality ex-ante in order to affect the incentives to contribute to the team output. The intuition behind our result is that heterogeneity in abilities typically lead to heterogeneity in optimal contributions. When the involved actors benefit to the same extent from the group output, equality in initial income may then lead to inequity as more able agents provide higher inputs and, in turn, have to bear higher costs.[3] But when agents are inequity averse, they have an incentive to reduce this inequality by adapting their contributions. This incentive effect of inequality, in turn, provides the possibility to use the distribution of initial income as a tool to guide contribution behavior. In particular, giving higher wealth to more able agents increases their incentive to contribute which is beneficial not only for the group as a whole, but also for the less able and initially disadvantaged agents as the contributions of the former are more valuable. In our welfare analysis, we show that there is an optimal degree of initial inequality favoring more able agents. This inequality is not only chosen by an utilitarian social planner but is also preferred by an egalitarian social planner as well as the agents themselves. Most strikingly, the optimal degree of inequality is increasing in the agents inequity concerns, i.e., the stronger the agents' inequity aversion the *larger* should be the difference in initial income.

The analysis of our model further shows that when agents are inequity averse and can coordinate on the Pareto-dominant equilibrium, the free-rider problem can be substantially

[1]For experimental evidence see for example Roth and Kagel (1995), Camerer (2003) and Engelmann and Strobel (2004). Using a more general notion of fairness, field evidence is given by e.g. Blinder and Choi (1990), Agell and Lundborg (1995), Campbell and Kamlani (1997), Bewley (1999) and Carpenter and Seki (2006). For a summary of the empirical evidence on social preferences see for instance Fehr and Schmidt (2002) and Sobel (2005).

[2]Undoubtedly, income is often distributed unequally among members of a group or a society. Likewise, people often differ in their skills affecting their ability to contribute to a joint project. For example, members of a team that work on a joint project might have different task-specific abilities determining the productivity of their chosen effort. Similarly, in a public good context like environmental protection, countries have different qualifications in fighting climate change, for instance different capabilities to resist deforesting the rainforest or different technological competencies to avoid carbon dioxide emissions.

[3]In the following we use the term inequality describing inequality in initial wealth, and the term inequity describing inequality in wealth after agents have contributed and received their benefits from the public good.

reduced. In particular, for intermediate levels of income inequality both agents exert higher efforts relative to the efforts maximizing their material payoffs. Finally, we demonstrate that when group composition is endogenous and agents can either be matched into homogenous or heterogenous groups, total contributions are independent of the group composition when the distribution of income is adapted to the group composition.

Our paper relates and contributes to the literature on behavioral contract theory (see Koszegi (2014) for a review), as well as to the literature on the interplay of equity and equality in social exchanges in general (see e.g. Homans (1958), Adams (1965), Konow (2000), Cappelen et al. (2007), or Konow et al. (2009)). In particular, several previous studies have shown that inequity aversion can affect agents' incentives to exert effort and, as a consequence, contract design in often non-trivial ways (see e.g. Fershtman et al. (2003), Itoh (2004), Grund and Sliwka (2005), Huck and Rey-Biel (2006), Demougin et al. (2006), Fehr et al. (2007), Charness and Kuhn (2007), Rey-Biel (2008), Dur and Glazer (2008), Mohnen et al. (2008), Kragl and Schmid (2009), Neilson and Stowe (2010), Bartling and von Siemens (2010), and Englmaier and Wambach (2010)). However, while almost all of these studies consider situations in which homogeneous agents interact with each other, we investigate a scenario where agents are heterogenous with respect to their abilities. As a result, while in most of the studies inequity aversion leads to more equal payment structures, our model shows that inequity aversion may in fact be a reason to introduce inequality ex-ante.

As already noted above the mechanism we analyze is different from the claim that it is unfair to provide equal wages ex-post to agents who have made unequal contributions. Indeed, Abeler et al. (2010) find that paying equal wages after an unequal performance may lead to inequity and, in turn, to substantially lower efforts and a decline in efficiency over time. But while this paper argues for inequality in ex-post performance rewards, our paper shows that it may even be optimal to introduce ex-ante inequality in the non-performance contingent wage components. Our model thus provides new insights on the question whether and when inequality can harm or facilitate cooperation. In that respect our results may also add to the understanding of sometimes heard statements arguing that unequal reward schemes provoke morale problems among co-workers leading to lower performances (e.g. Akerlof and Yellen (1990), Bewley (1999)). While this is indeed true in our model when agents' abilities are homogeneous, the opposite holds if abilities differ across agents. Overall, our paper highlights the importance of taking into account heterogeneity when analyzing social interactions suggesting that (in)equality does not necessarily imply (in)equity and vice versa.

The remainder of this paper is structured as follows. In the next section, we proceed by describing the model. After that, Section 3 presents the equilibrium analysis. In Section 4, we compare the effort levels chosen by inequity averse and purely selfish agents. Section 5 analyzes preferences for redistribution and examines the effects of distribution policies and group composition on the provision of the group output and social welfare. Section 6 concludes.

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2 The Model

Two agents i and j can both contribute to a group output. An agent's contribution depends on her effort e_i and her ability a_i. Individual effort costs are linear in the exerted effort and equal to $c \cdot e_i$, $c \in \mathbb{R}^+$. The group output is determined by the sum of both agents' contribution:[4]

$$a_i \sqrt{e_i} + a_j \sqrt{e_j}.$$

Both agents directly benefit from a higher group output, each receiving a share η indicating their valuation of the joint project. While in a public good context η represents how much agents benefit from their contributions to the public good (*marginal per capita return),* in a team context η represents, e.g., the degree of team identification, the intrinsic benefit of the work output, or a performance-contingent team compensation. In any case, we treat η as being exogenously given and identical for both agents. In addition, each agent i is provided with an initial income w_i. Both agents are inequity averse with a Fehr and Schmidt (1999) utility function. An agent's utility therefore is

$$U_i(e_i, e_j) = w_i - c \cdot e_i + \eta \cdot (a_i \sqrt{e_i} + a_j \sqrt{e_j}) - \upsilon(w_i - c \cdot e_i - w_j + c \cdot e_j)$$

where the "psychological costs of inequity" are

$$\upsilon(\Delta) = \begin{cases} -\alpha \cdot \Delta & if \quad \Delta < 0 \\ \beta \cdot \Delta & if \quad \Delta > 0 \end{cases},$$

as the difference in "material payoffs" is

$$\begin{aligned} \Delta &= \left(w_i - c \cdot e_i + \eta \cdot \left(a_i \sqrt{e_i} + a_j \sqrt{e_j}\right)\right) - \left(w_j - c \cdot e_j + \eta \cdot \left(a_i \sqrt{e_i} + a_j \sqrt{e_j}\right)\right) \\ &= w_i - c \cdot e_i - w_j + c \cdot e_j. \end{aligned}$$

The constant α measures the marginal psychological costs of disadvantageous inequity and β that of advantageous inequity. Following Fehr and Schmidt (1999) we assume that $\alpha \geq \beta \geq 0$. Additionally, we assume that $\beta \leq \frac{1}{2}$.[5] Our framework thus corresponds to a standard Fehr/Schmidt model where the agents are inequity averse about final payoffs net of effort costs.

[4]Note that this framework can be equivalently transformed to a setting with linear production functions and quadratic costs. To see that, let agent i's contribution to the public good be $g_i = a_i \sqrt{e_i}$ such that the total contribution is $g_i + g_j$ and the agent's (material) payoff is $\eta \cdot (g_i + g_j) - c \cdot \left(\frac{g_i}{a_i}\right)^2$. This is then a special case of a standard non-linear public goods game. The chosen transformation just simplifies the exposition.

[5]Note that $\beta > \frac{1}{2}$ connotes a very strong form of inequity aversion implying that ex-post, agents would be willing to donate parts of their wealth to less wealthy group members up to the point where wealth levels are completely equalized (compare Rey-Biel (2008)). We discuss implications of this assumption at the end of Section 3.

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In the following, we discuss the important underlying assumptions of our model. First, note that we focus on situations in which we cannot differentiate to what extend people benefit from achieving a joint output but we can treat them differently with respect to the uncontingent income.[6] Second, we consider a scenario in which efforts are determined endogenously but where the agents' ability are exogenously given. We thus interpret a_i as an agents' talent or innate ability that does not depend on, e.g., the agents' previous efforts.[7] Third, we assume that agents care about inequality in final outcomes. While this seems to be a natural focal reference point, in heterogeneous situations it might be less focal as multiple (potentially conflicting) fairness norms are conceivable (see e.g. Reuben and Riedl (2013), Hennig-Schmidt et al. (2013)). This is an important empirical question as theoretical predictions crucially depend on the specific reference point considered. Yet, for the type of heterogeneity studied in this paper, evidence from two recent papers suggest that even in this setting the norm of equal outcomes may prevail. For the case of income heterogeneity, Reuben and Riedl (2013) provide evidence from a questionnaire study showing that the norm of "equality of earnings" is important even when initial wealth is distributed unequally. Kölle (2015) provides experimental evidence suggesting that people care about equality in final outcomes even when abilities are heterogeneous. As a result, while we acknowledge that especially in asymmetric settings several fairness norms may arise, we believe that in our setting equality of earnings is a reasonable and natural reference point that guides behavior.

3 Equilibrium Analysis

Each agent *i* maximizes

$$\max_{e_i} w_i+\eta\cdot\left(a_i\sqrt{e_i}+a_j\sqrt{e_j}\right)-c\cdot e_i-\upsilon\left(w_i-c\cdot e_i-w_j+c\cdot e_j\right).$$

The function is continuous but not continuously differentiable as it has a kink at $e_i=\frac{\Delta w_i}{c}+e_j$ where *i* attains the same utility as *j*. Off the kink, the second derivative with respect to e_i is $-\frac{\eta a_i\sqrt{e_i}}{4e_i^2}<0.$ As the right-sided derivative at the kink is strictly smaller than the left-sided derivative, the function is strictly concave. From investigating the best response functions we obtain the following result:

Proposition 1 *(i) If the difference in initial income* $\Delta w_i = w_i - w_j$. *is either sufficiently large or sufficiently small there are unique Nash equilibria characterized by*

[6]This, for example, is always the case if there is an intrinisc interest in the joint output but this joint output is not verifiable. Even in such situations base income levels can be varied, but the degree to which individuals care for the overall output cannot be affected by a contract designer as easily.

[7]While in our static setting this seems to be a reasonable assumption, in a more dynamic setting it is conceivable that previous efforts might endogenously affect the agents' abilities and, in turn, could also affect the agents' social reference point.

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$$\left(e_i^*, e_j^*\right) = \begin{cases} \left(\frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2}, \frac{\eta^2 a_j^2}{4(1+\alpha)^2 c^2}\right) & if \Delta w_i \geq \Delta w_H \equiv \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right) \\ \left(\frac{\eta^2 a_i^2}{4(1+\alpha)^2 c^2}, \frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2}\right) & if \Delta w_i \leq \Delta w_L \equiv \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right) \end{cases}.$$

where $\Delta w_L < \Delta w_H$. *In these equilibria both agents receive uneqal payoffs.*

(ii) For intermediate values $\Delta w_i \in \left]\Delta w_L, \Delta w_H\right[$ *there is a continuum of Nash equilibria. In each of these equilibria both agents receive the same payoff. Specifically, any pair* $\left(\overline{e}_i^*, \overline{e}_j^*\right)$ *of effort levels such that*

$$\max\left\{\frac{\eta^2 a_i^2}{4(1+\alpha)^2 c^2}; \frac{\eta^2 a_j^2}{4(1+\alpha)^2 c^2} + \frac{\Delta w_i}{c}\right\} \leq \overline{e}_i^* \leq \min\left\{\frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2}; \frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2} + \frac{\Delta w_i}{c}\right\} \ and$$

$$\overline{e}_j^* = \overline{e}_i^* - \frac{\Delta w_i}{c} \tag{1}$$

is an equilibrium.

Proof: See the appendix.

First of all, note that equilibrium effort levels are affected by the initial income levels w_i and w_j only through the income differentials Δw_i. The reason is that marginal returns to effort are unaffected by absolute income – but are affected by income differentials as these change the marginal effects of the exerted efforts on the ex-post inequality in payoffs.

To understand the result in more detail it is useful to illustrate some specific cases. Consider first a scenario in which both agents are purely selfish, i.e., $\alpha = \beta = 0$, but might differ in ability. In this scenario there is a unique Nash equilibrium and efforts are given by

$$e_i^{selfish} = \frac{\eta^2 a_i^2}{4c^2} \text{ and } e_j^{selfish} = \frac{\eta^2 a_j^2}{4c^2}.$$

Hence, purely selfish agents' effort choices are not affected by the distribution of initial wealth as they only consider their marginal returns when choosing their efforts. Furthermore, more able agents work harder as their marginal product of output is higher and, in turn, incur higher costs. But as agents always benefit equally from the group output, if initial wealth is distributed equally, i.e., $\Delta w = 0$, agents will end up with unequal payoffs in equilibrium.

Another interesting special case is when both agents are inequity averse but have identical abilities, i.e., $a_i = a_j = a$. In that case, an equal wealth distribution of $\Delta w = 0$ always guarantees an "equitable equilibrium" in which both agents end up with the same payoff as $\Delta w_L < 0 < \Delta w_H$. However, this equilibrium is never unique. The reason is that inequity averse agents have some interest to adapt their own effort according to the group member's effort in order to avoid disutility from inequity. This leads to a coordination problem as the reaction functions are upward sloping and, thus, multiple equilibria naturally arise.

If, however, the agents differ in their abilities, equity cannot always be attained when wealth is distributed equally. As described above, the reason is that different abilities lead to different optimal effort levels and, hence, costs. In this case, an equal distribution of initial wealth then leads to inequality ex-post in which the more able agent is worse off.[8] When the difference in abilities is not too large, the less able agent may still match the more able agent's effort level to generate equity. But if the ability difference is too large (or inequity aversion is too weak) she will not have a sufficiently strong incentive to do this. In that case, giving higher wealth to the more able agent is necessary to compensate her for her higher effort costs and to make equitable outcomes attainable. The main scope of the rest of the paper is to investigate such cases in which agents care about equity but differ in their abilities. In this case the distribution of wealth (or wages) matters and can be used to align behavior.

Figure 1 summarizes the sustainable equilibrium effort levels of both agents i and j as a correspondence of Δw_i for an example in which agent i is more able than agent j, i.e., $a_i > a_j$.[9] As shown in Proposition 1, for small values of Δw_i $(= -\Delta w_j)$ below Δw_L there is a unique inequitable equilibrium with $e_i^* = \frac{\eta^2 a_i^2}{4(1+\alpha)^2 c^2}$ and $e_j^* = \frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2}$, and for large values of Δw_i above Δw_H there is a unique inequitable equilibrium with $e_i^* = \frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2}$ and $e_j^* = \frac{\eta^2 a_j^2}{4(1+\alpha)^2 c^2}$. For intermediate values of $\Delta w_i \in \,]\Delta w_L, \Delta w_H[$, in contrast, a continuum of equitable equilibria exist in which both agents receive the same payoff.

Proposition 1 has several interesting implications. First, when considering the case of equitable equilibria it is interesting to note that the set of efforts defined by (1), as well as the interval of wage differentials $\Delta w_i \in \,]\Delta w_L, \Delta w_H[$ that still lead to equitable outcomes ex-post, is the larger the higher the agents' degree of inequity aversion. This means that the more the agents care for equity, the larger is their willingness to adjust their efforts to reduce inequity, and, therefore, the larger can be the maximal inequality in initial income the agents are willing to offset to end up in an equitable equilibrium. To see this formally, note that the lower boundary of the equilibrium set in (1) is decreasing in α as more "envious" agents are willing to reduce their efforts to avoid being worse off than their group member. Analogously, the upper boundary is increasing in β as more "compassionate" agents are more willing to raise their efforts to reduce a group member's disadvantage.[10]

Second, when considering inequitable equilibria, it is worth mentioning that also in this case both agents adapt their efforts. While the contribution of the favored agent (say agent i)

[8]To see that formally, note that the lower boundary Δw_L can exceed zero (or the upper boundary Δw_H can become smaller than zero) when the abilities differ strongly and inequity aversion is not too strong.
[9]The figure shows a setting in which $a_i = 12$, $a_j = 10$, $\alpha = 0.4$, $\beta = 0.2$, $\eta = 0.2$, and $c = 1$.

$e_i^* = \frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2}$ is increasing in the degree of "compassion" β, the contribution of her disadvantaged counterpart $e_j^* = \frac{\eta^2 a_j^2}{4(1+\alpha)^2 c^2}$ is decreasing in the degree of "envy" α. Still, they here end up in a situation which is inequitable ex-post. This, however, is only the case when the initial inequality in wealth is sufficiently large.

Finally, when investigating the continuum of equitable equilibria, it is important to note that as both agents attain identical payoffs in every such equilibrium, they prefer the same one. Consequently, it is important to compare the different feasible equitable equilibria with respect to the agents' utility which leads to the following result:

Corollary 1 *As long as the degree of compassion is not too strong* $\left(\beta \leq \frac{1}{2}\right)$, *the equitable, quilibrium in which the agents material payoff is highest is always Pareto optimal within the set of Nash equilibria.*

Proof: See the appendix.

To understand this result note that there is a free-rider problem which is particularly strong when agents are selfish. Inequity aversion helps to overcome this free-rider problem as it allows agents to coordinate on higher effort levels which come closer to the first best. As long as β does not exceed $\frac{1}{2}$ the highest feasible equilibrium is still lower than the first-best and therefore is preferred by the agents.[11] With a β larger than $\frac{1}{2}$, however, inequity aversion becomes so strong that an agent even would have an incentive to match an inefficiently high effort level chosen by her group member even though both would be better off with a lower effort. Therefore, both agents benefit from playing the equitable equilibrium with the highest sustainable effort level when they are not extremely "compassionate". This effort level is equal to $\min\left\{\frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2}; \frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2} + \frac{\Delta w_i}{c}\right\}$ and, hence, strictly increasing in the degree of advantageous inequity aversion β.

It is, of course, an important empirical question whether agents can coordinate on the Pareto-best equilibrium. A number of experimental papers (see e.g. Cooper et al. (1992), Blume and Ortmann (2007)) have found that simple ex-ante cheap talk communication very frequently

[10]To see the effect on the interval of wage differentials, note that the lower boundary $\Delta w_L = \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right)$ is decreasing in both α and β and the upper boundary $\Delta w_H = \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right)$ is increasing in both.

[11]The agents' first-best efforts can be derived by maximizing $w_i + w_j - c \cdot e_i - c \cdot e_j + 2\eta \cdot \left(a_i\sqrt{e_i} + a_j\sqrt{e_j}\right)$ and are given by $e_i^{FB} = \frac{\eta^2 a_i^2}{c^2}$ and $e_j^{FB} = \frac{\eta^2 a_j^2}{c^2}$.

leads to the choice of the Pareto-efficient Nash equilibrium in coordination games.[12] Yet, there also might be cases in which coordination fails, for instance, when there are no focal points and no pre-play communication. In these cases equity may come at a cost as it raises the danger of coordination failure. In the remainder of the paper and, in particular, in the welfare analysis in Section 5, however, we focus our analysis on the Pareto-best implementable equilibria. We acknowledge that it may be more difficult that agents coordinate on Pareto-dominant equilibria in a game where utility includes disutility from inequity and not only purely material outcomes. Note, however, that equilibria here are Pareto-ranked also with respect to the purely material outcomes in the same order as in any of the multiple equilibria there is equity in material outcomes. As a result, imposing Pareto-efficiency with respect to purely material outcomes as a refinement criterion selects the same equilibrium outcomes.

4 Do Inequity Averse Agents Contribute More?

Before we proceed to the welfare analysis, we compare the attained effort levels with those chosen by purely selfish agents to study the effects of inequity aversion on the motivation to contribute to the group output. From Proposition 1 as well as Corollary 1 we know that the highest attainable equilibrium effort levels of inequity averse agents (e_i^*, e_j^*) are given by

$$\begin{cases} \left(\frac{\eta^2 a_i^2}{4(1+\alpha)^2 c^2}, \frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2}\right) & if\,\Delta w_i < \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right) \\ \left(\frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2} + \frac{\Delta w_i}{c}, \frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2}\right) & if\,\Delta w_i \in \left[\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right), \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)\right] \\ \left(\frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2}, \frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2} - \frac{\Delta w_i}{c}\right) & if\,\Delta w_i \in \left[\frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right), \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right)\right] \\ \left(\frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2}, \frac{\eta^2 a_j^2}{4(1+\alpha)^2 c^2}\right) & if\,\Delta w_i > \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right) \end{cases} \quad (2)$$

as depicted by the solid upper boundary of the graphs in Figure 1. Note that both functions are continuous and weakly monotonic.

Purely selfish agents' effort choices, in contrast, are not affected by the distribution of initial wealth as they consider only their marginal returns when choosing their efforts. Recall that efforts of purely selfish agents are given by

$$e_i^{selfish} = \frac{\eta^2 a_i^2}{4c^2} \text{ and } e_j^{selfish} = \frac{\eta^2 a_j^2}{4c^2}. \quad (3)$$

By comparing these effort levels of selfish agents with those of inequity averse agents as given by (2) we obtain the following result:

Proposition 2 *For intermediate wealth differentials Nash equilibria exist in which both agents contribute more when they are inequity averse as compared to purely selfish agents.*

[12] See also Demichelis and Weibull (2008) for a theoretical argument based on lexicographic preferences for honesty.

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If $\Delta w_i \geq \frac{\eta^2 a_i^2}{4(1-\beta)^2 c} - \frac{\eta^2 a_j^2}{4c}$, *inequity aversion motivates agent i to exert higher efforts but de-motivates agent j. The opposite holds if* $\Delta w_i \leq \frac{\eta^2 a_i^2}{4c} - \frac{\eta^2 a_j^2}{4(1-\beta)^2 c}$.

Proof: See the appendix.

Hence, the initial income differential Δw_i is crucial to determine how inequity averse agents adapt their effort choices relative to the efforts maximizing their material payoffs. For intermediate levels of initial income inequality, inequity aversion can help to reduce the free-rider problem as both agents contribute more – provided that they can coordinate on the Pareto-superior equilibrium.

If initial income inequality becomes stronger, however, inequity aversion leads to an asymmetric reaction as the favored agent chooses a higher effort than the level maximizing her material payoff, and the disadvantaged agent contributes less than would be optimal from a payoff maximizing perspective. Depending on the parameter constellation, the motivating effect of the favored agent may or may not outweigh the de-motivating effect of the disadvantaged one. If, for instance, envy plays a bigger role relative to "compassion" (i.e. if α is large relative to β the de-motivating effect will always dominate. If, however, the role of "compassion" becomes more important (i.e. if β becomes relatively large) and inequity favors the more able agent the opposite holds.[13] These results are summarized in Figure 2 showing the aggregate group output for selfish agents (dotted line) and inequity averse agents for an agent with a high β (panel A) and a low β (panel B - the other parameters are the same as used to plot Figure 1). As illustrated in Panel A, when β is high inequity aversion leads to a higher group output even at high levels of initial wealth inequality but only if this favors the more able agent. When β becomes small, however, this is no longer the case as illustrated in panel B.

It is further interesting to note that the demotivating effect described in the above may arise for the more able agent even when she receives a higher initial wealth than her less able colleague: The lower boundary for Δw_i in Proposition 2 is larger than zero if

$$\frac{\eta^2 a_i^2}{4c} - \frac{\eta^2 a_j^2}{4(1-\beta)^2 c} > 0 \iff a_i > \frac{a_j}{1-\beta}.$$

Hence, when a_i is much larger than a_j or when β is sufficiently small, the more able agent reduces her effort below $e_i^{selfish}$ unless Δw_i exceeds a *strictly positive* cut-off value. Put differently, the more able agent has to be paid sufficiently more than her colleague or otherwise will reduce her effort below the selfishly optimal level. To understand the reason for this effect, note again that the payoff maximizing effort is always larger for the more able

[13]To see that, note that when inequality is large total output is larger when agents are inequity averse iff

$$a_i \frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2} + a_j \frac{\eta^2 a_j^2}{4(1+\alpha)^2 c^2} > a_i \frac{\eta^2 a_i^2}{4c^2} + a_j \frac{\eta^2 a_j^2}{4c^2}.$$

agent as her marginal returns to effort are higher. As both equally benefit from the group output, she is worse off than her less able colleague when both have the same initial income. Importantly, this inequality in final outcomes is the higher the larger the difference in abilities (i.e. the larger a_i relative to a_j) and, hence, efforts. When agents are inequity averse, they both suffer from this inequality. If the less able colleague is sufficiently "compassionate", i.e., β is high, she puts in a high enough effort such that the more able agent will still choose an equilibrium effort level above $e_i^{selfish}$ and both group members can coordinate on a superior equilibrium. But when the less able colleague does not suffer too much from earning more, i.e., β is small, her effort is not high enough to compensate for the inequality in initial wealth. In that case, the more able agent can only reduce inequity by lowering her effort. As a result, not awarding the more able agent more money up front may lead to an unfair distribution of payoffs and, in tum, to lower efforts.

5 Optimal Wealth Differentials and Group Composition

We proceed by analyzing preferences for redistribution of the agents (Section 5.1) and a social planner or principal (Section 5.2) who can decide on the distribution of initial wealth. After that, in Section 5.3, we examine the effect of group composition under the optimal distribution of initial wealth.

5.1 Individual Preferences for Redistribution

We start by studying the agents' ex-ante preferences on the initial income differential Δw_i when they take into account their equilibrium effort choices. These considerations will be a useful starting point for the later welfare analysis. To do that, it is instructive to consider a situation in which a certain budget $W = w_i + w_j$ can be distributed between the two agents. By inserting the equilibrium effort choices (2) into the agents' utility functions we can describe their utility as a function of the initial income differential Δw_i Analyzing the shape of the indirect utility functions we obtain the following result:

Proposition 3 *If agents can coordinate on pareto-dominant equilibria, each agent's equilibrium payoff is non-monotonic in the wealth differential* Δw_i. *If* $\Delta w_i < \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)$ or $\Delta w_i > \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right)$ *an agent i's utility is strictly increasing in* Δw_i. *But between these two cut-off values it is strictly decreasing such that in this interval agent i is better off when having a lower income. Both agents' utility functions attain a local maximum at* $\Delta w_i^* = \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)$.

Proof: See the appendix.

Proposition 3 shows that for extreme values of Δw_i each agent always benefits from a redistribution in her favor as there is a straightforward conflict of interest between both agents. For intermediate levels of Δw_i between Δw_L and Δw_H, however, agents sometimes can benefit from a redistribution of initial wealth to their disadvantage. This is particularly the case if the agents differ in their abilities and when the less productive agent sacrifices part of her initial wealth and transfers it to her more able colleague. The reason is that in this intermediate interval, only equitable equilibria exist in which both agents' interests are fully aligned and in which any inequality in initial wealth will be endogenously offset by the agents' adapted effort levels. But shifting more wealth to the more able group member increases the latter's willingness to contribute to the group output, and as her contributions are more valuable this, in turn, is also beneficial for the less able agent.[14] Of course, this result only holds if the transfer of wealth is not too large. Within the set of equitable equilibria, Proposition 3 shows that when agens can coordinate on an equilibrium leading to the highest contributions, all values of Δw_i within this interval are Pareto-dominated by an initial income differential of $\Delta w_i^* = \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)$ which alignes the differences in initial wealth to the differences in the agents' abilities. These results are graphically illustrated in Figure 3 depicting the equilibrium utilities of agent i (solid line) and agent j (dashed line) as a function of Δw_i.[15]

5.2 Optimal Distribution of Wealth

We now study a situation in which an external authority can decide on the distribution of income. We do that by first considering a social planner who has a social welfare function which is either egalitarian (i.e. who wants to maximize the utility of the least well-off) or utilitarian (i.e. wants to maximize the sum of both agents' utility). It directly follows from Proposition 3 that such a social planner always has a dominant choice:

Corollary 2 *If agents can coordinate on pareto-dominant equilibria, a social planner who is either utilitarian or egalitarian will set* $\Delta w_i^* = \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)$.

Proof: See the appendix.

Based on Proposition 3, it is straightforward to see that within the set of initial income differentials inducing equitable equilibria, both egalitarian and utilitarian planners will always choose $\Delta w_i^* = \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)$ as at this spread, both the sum and the minimum of the agents' utilities are maximized. Any initial wealth differential which is not inducing an equitable equilibrium is always dominated by this choice. For an egalitarian social planner the reason is that the utility of the least well off agent is always lower in an inequitable equilibrium. Likewise, for an utilitarian social planner the reason is that in an inequitable equilibrium which, w.l.o.g., favors agent j, the marginal gain from transferring money to

[14]To see that formally, note that the local maximum at $\Delta w_i^* = \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)$. is always strictly positive if, w.l.o.g., agent i is the more able agent, i.e., $a_i > a_j$. In that case, there is a non-empty interval to the left of Δw_i^* such that both agent's utility is strictly increasing in Δw_i.

[15]The figure shows a setting in which $a_i = 12$, $a_j = 10$, $\alpha = 0.4$, $\beta = 0.2$, $\eta = 0.2$, and $c = 1$.

agent $i \frac{\partial u_i}{\partial \Delta w_i} = \frac{1}{2} + \alpha$ is always larger than j's marginal loss which is equal to $\frac{1}{2} - \beta$ (see (11)). This result is also illustrated in Figure 3 showing that for extreme values of Δw_i, the slope of the utility function of the disadvantaged agent is always steeper than the one of the favored agent.

Corollary 2 has several interesting implications. First, note that even an egalitarian social planner who only considers the utility of the least well off individual should allow for inequality in initial income. The reason is that it is precisely this inequality in initial income that induces an equilibrium in which equity is attained ex-post and in which the more able agent is willing to contribute more, which in the end benefits both agents.[16] Second, it further directly follows from Corollary 2 that the implementation of an egalitarian wealth distribution policy is only optimal if the group considered is completely homogenous in terms of abilities. If, instead, agents differ in their abilities, an egalitarian wealth distribution has detrimental effects and should be replaced by a distribution taking into account the difference in agents' abilities favoring more able agents. Finally, note that the optimal difference in initial wealth is *increasing* in the agents' degree of advantageous inequity aversion β but independent of α. The intuition behind this is that within the set of equitable equilibria, the highest attainable pair of efforts at which no agent has an incentive to deviate by unilaterally reducing her own effort level is increasing in β. The reason is that the higher the value of β the weaker the incentives for the favored agent to deviate, and, therefore, the stronger the incentive effect of wealth inequality. The degree of advantageous inequity aversion α, in contrast, does not affect the optimal wealth differential. This is due to the fact that the "binding" best response consideration is for both players determined by a deviation to one's own advantage. That is, any potential deviation to a lower effort level that increases a player's material outcome leads to inequity in favor of the deviating player which, in turn, causes psychological costs which are determined by β and not by α.

In a similar analysis to the one above, it further can be shown that a selfish principal whose profits are some strictly monotonic function of the group output and who has to take into account the agent's participation constraints chooses the same wage differential $\Delta w_i^* = \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)$, even when both reservation wages are identical. The reasoning follows exactly the same line of thoughts: (i) at this wage differential joint output is maximized and (ii) the utility of the least well off agent is also maximized – and this utility determines the binding participation constraint. Hence, a purely self-interested principal pays more able agents more money even when the more able agent has an identical reservation wage as the less able one.

5.3 The Optimal Group Composition

So far, we only considered how income should be distributed treating the composition of agents within a group as exogenously given. However, it is also interesting to study the case

[16] This observation bears some resemblance to the result by Andreoni (1990) who argues that redistribution of income will increase the total contribution if it benefits the more altruistic individuals.

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in which the formation of groups itself can be determined as well. This might be the case either if a principal or social planner has the power to dictate group composition, or if agents have the opportunity to self-select into different groups or incentive systems (see e.g. Kocher et al. (2006), Dohmen and Falk (2011)). A straightforward conjecture is that group composition matters for the willingness to contribute if the agents are inequity averse towards their fellow group members. To investigate this, we consider a simple situation in which there are four agents - two of high ability and two of low ability - that can be assigned into two groups of two.[17] By comparing total contributions, we can derive the following result:

Proposition 4 *If all agents have the same initial income, total contributions are always higher with homogenous than with heterogenous groups. But when income can be adapted optimally, total contributions are independent of the group composition.*

Proof: See the appendix.

Proposition 4 shows that when the income level is fixed and equally distributed it is beneficial to have homogenous groups. The reason is straightforward from the analysis above. Heterogeneity in abilities leads to a de-motivation of the more qualified agent when income is equally distributed. By matching agents into homogenous teams, this demotivational effect can be avoided and group homogeneity helps the agents to coordinate on more favorable equilibria. It is, however, interesting to note that group composition is irrelevant for total contributions when the income level can be optimally adapted. In this case, the disadvantage of the more able agent can be entirely offset and, in turn, motivation to contribute is restored to the levels attainable in homogenous groups.[18]

6 Conclusion

This paper contributes to the literature investigating the effects of group heterogeneity on cooperation. In particular, we analyze the effects of income inequality on the incentives to contribute to a group output when agents are inequity averse and differ in their abilities. Our main result is that in this case from an individual as well as from the perspective of an egalitarian or utilitarian social planner, it is optimal to introduce ex-ante inequality in income. The reason is that more able agents exert higher efforts as their marginal returns to effort are higher and, in turn, incur higher costs. But since all group members benefit equally from the group output, allocating agents of different abilities the same initial income lead to unequal outcomes ex-post. When agents are inequity averse this can de-motivate the more able agent which, as a consequence, has detrimental effects on the overall performance as their contributions are more valuable. Giving higher wealth to more able agents, in contrast, can motivate them to exert higher efforts which increases the total group output. This, in

[17]Note that in this regard, heterogeneity refers to the difference in agents' abilities. For studies analyzing optimal team composition with heterogeneity in agents' preferences see for instance Fershtman et al. (2006) and Brunner and Sandner (2012). Bartling (2012) analyzes how agents' (social) preferences can be endogenously affected by the internal design of organizations.

[18]Besides that, there might be other channels through which performance can be affected by group composition. For example, as argued by Hamilton et al. (2003), "worker heterogeneity could shape team productivity by facilitating mutual learning or by influencing the group production norm." Using a large dataset, the authors find that teams with a greater spread in ability are more productive than teams of homogeneous agents.

turn, is also beneficial for the initially disadvantaged and less able agents. Interestingly, the stronger the agents' inequity aversion, the stronger is also the incentive effect of inequality and the larger should be the difference in initial income. Compared to the case when agents are purely self-interested we show that when the distribution of initial wealth is optimally aligned to the differences in abilities, the group output is higher when agents care about equity as inequity aversion helps them to reduce the free-rider problem and to coordinate on higher contribution levels.

Insights from our results cast doubt on simple statements sometimes heard in practice claiming that inequality among the members of a group is demotivating when people care for fairness. While this is indeed true for very large income differentials in our model, the opposite can also be the case when income differentials are too small. Besides that, our results also may cast some light on the discussion about distributional politics (Alesina and Angeletos (2005), Durante et al. (2014)) and the effects on citizens' willingness to voluntary donate to a common good. Some previous studies (e.g. Warr (1983) and Bergstrom et al. (1986)) have argued that the total provision of a public good is independent of the distribution of income. In contrast, our results indicate that equality in income may crowd-out the motivation to contribute. But allowing for inequality may (up to some point) have positive effects on the citizens' willingness to work for the common good. However, our model also shows that this is the case only if the higher income is in the hands of those who can provide the most valuable contributions.

Finally, it is important to point out that we study the role of asymmetric innate abilities such as cognitive skills. If the marginal productivities of the agents are endogenously determined as, for instance, by human capital investments on an ex-ante stage, different mechanisms than the ones studied in this paper may come into play. For instance, a high productivity may then signal prosocial intentions and thus affect behavior beyond its direct impact on the public good and the degree of inequity. It should be an interesting topic for future research to study such dynamic settings in more detail.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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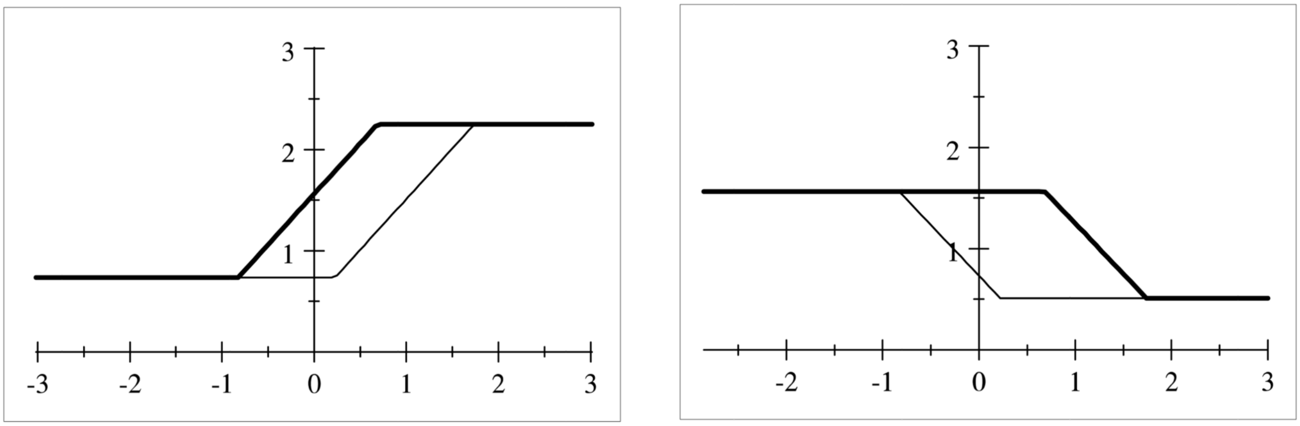

Figure 1.
Effort choice of agent *i* (left) and *j* (right) depending on Δw_i

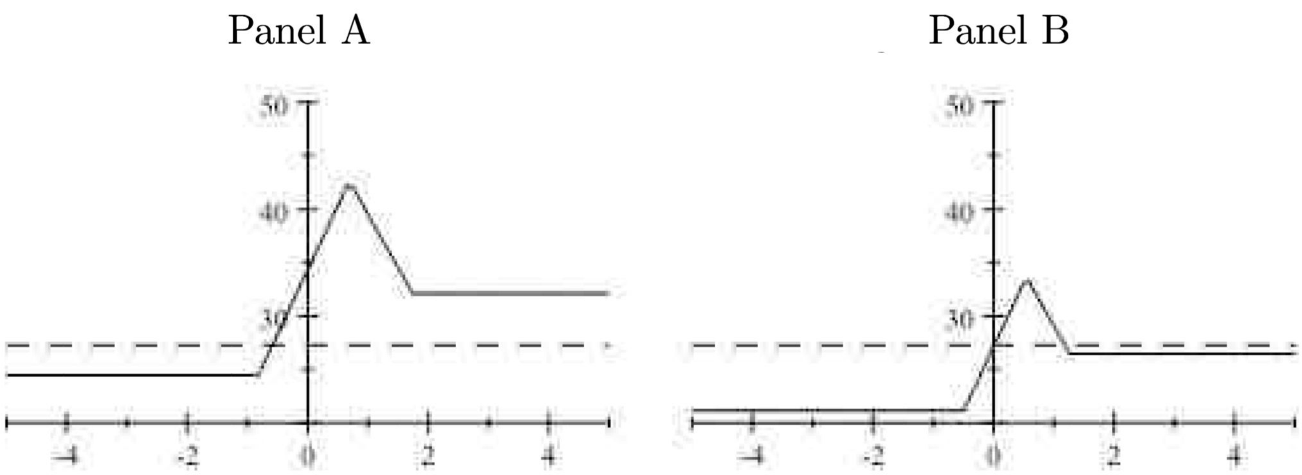

Figure 2.
Total group output as function of Δw_i for $\beta = 0.2$
Total group output as function of Δw_i for $\beta = 0.1$

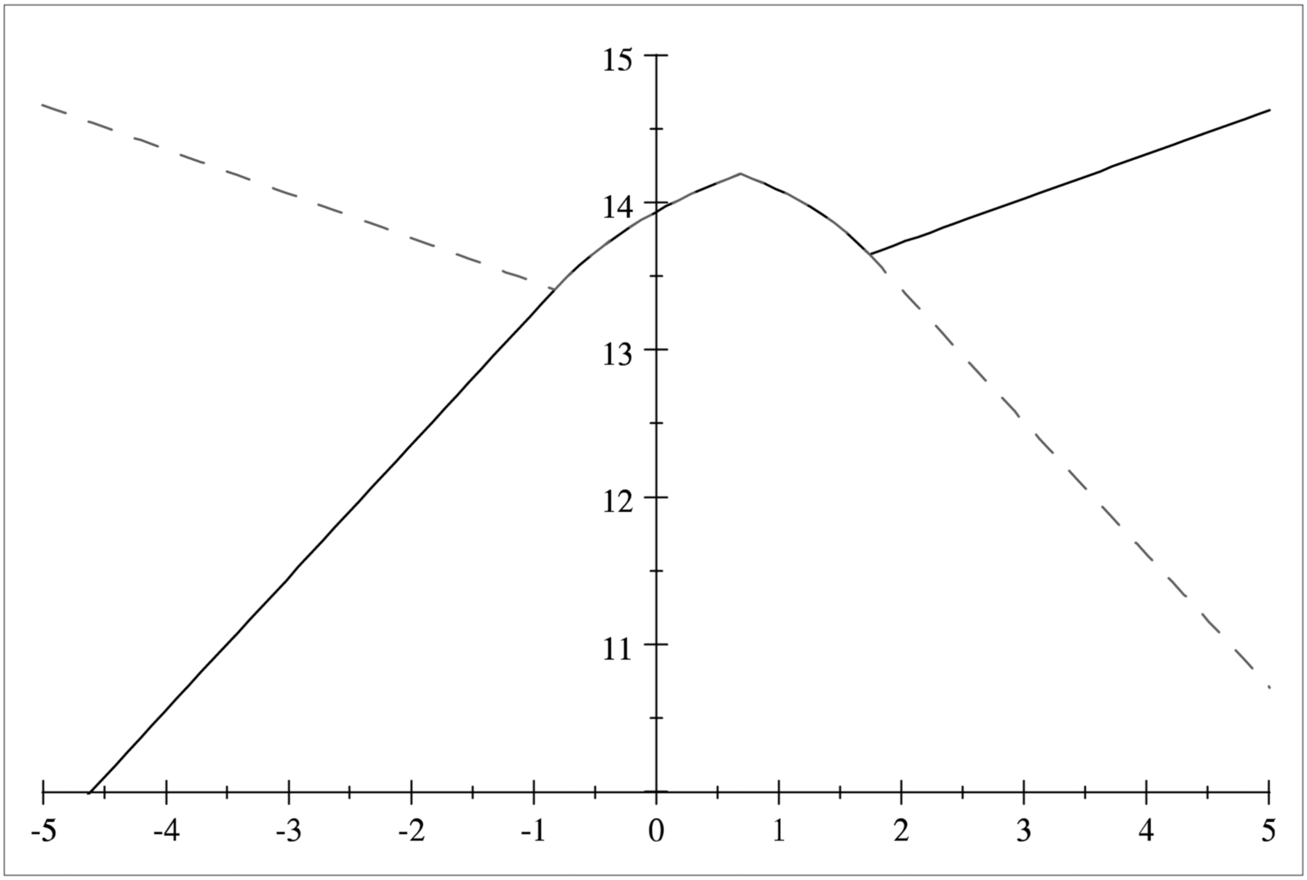

Figure 3.
Agent *i*'s (solid) and *j's* utilities (dashed) in equilibrium depending on Δw_i

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