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Risk aversion when preferences are altruistic[☆]

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ABSTRACT

We link risk preferences, as measured by the coefficient of relative risk aversion, with the prevalence and intensity of altruism, which we operationalize by the propensity of a person to voluntarily transfer part of his wealth to another person. To quantify the intensity of altruism, we incorporate a coefficient $\alpha_i \in (0,1)$ in the utility function of an altruistic person i. This coefficient measures the extent to which the altruistic person derives utility from the wellbeing of another person. We show that an altruistic person who is an active donor (benefactor) is more risk averse than a non-altruistic person, and that the relative risk aversion of altruistic person i is an increasing function of α_i. In addition, we show, in line with intuition, that person j who is the beneficiary of an altruistic transfer is less risk averse than a comparable person who is not a beneficiary of an altruistic transfer, and that the relative risk aversion of person j is a decreasing function of α_i. When we analyze a setting in which two persons are altruistic towards each other, we find that, in essence, the risk aversion consequences of mutual altruism do not differ from the risk aversion consequences of unilateral altruism.

1. Introduction

In a recent series of four papers, Stark and Zawojska (2015), Stark and Szczygielski (2019), Stark et al. (2019), and Stark (2020), the attitude of people towards risk taking was studied under the assumption that risk-taking behavior is conditioned by social preferences. The way in which this consideration was incorporated was to introduce relative wealth as a variable: a person's own wealth matters, but so does how a person's wealth compares to the wealth of others who are positioned higher up in the wealth distribution.

What these papers have in common is to show that in the formation of risk-taking preferences, relating to others matters, and that subject to the modeling used, it is possible to sign the effect of that relationship on attitudes towards risk taking. In all the models, the utility of the reference person was expanded into an additively separable function where the added "social ties" component was accorded a weight reflecting its importance. And that component entered the function negatively: low relative wealth, low rank, and low status affect wellbeing adversely. Missing from these inquiries is a study of the case in which a person relates to others *positively*, namely altruistically. The need to conduct such an inquiry arises not merely because altruism is prevalent and plays an important role in the affairs of families and other groups, but because it is unclear in which direction altruism will influence the inclination of an altruistic person to resort to risky pursuits. Will this person's risk-taking behavior be different if the utility of another person does not enter his utility function? Does exhibiting altruism *cause* a person to become more relatively risk averse because a risky undertaking turning sour will also hurt his ability to make altruistic transfers? Or does altruism induce a person to resort to risky behavior because the reward for a successful outcome is amplified by the outcome facilitating a bigger transfer to the beneficiary of the altruistic transfer?

There is an obvious presumption that the beneficiary of altruistic transfers will be less averse to risks because the altruistic channel operates in a manner similar to that of an insurance arrangement. This response and the associated moral hazard were already studied a long time back (Bernheim and Stark, 1988). In Section 3 we address this issue. However, the attitude towards risk taking of the altruistic person requires close scrutiny. Holding

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other variables constant, is an altruistic person more risk averse than a comparable person who is not altruistic? And how does the risk aversion of an altruistic person change when the strength of his altruism changes? In Section 2 we provide responses to these questions.[1] In the Appendix we draw on the structure and findings of Sections 2 and 3 to ask what happens to risk aversion under mutual altruism, in particular what, qualitatively, happens to aggregate risk-taking behavior when altruism is present as opposed to when it is absent.

2. The relative risk aversion of an altruistic person

Suppose that altruistic person i derives utility from his wealth, denoted by $w_i>0$, and from the utility of person j. By $\alpha_i\in(0,1)$ we denote the intensity of altruism. The complementary weight, $(1-\alpha_i)$, is accorded to the utility that person i obtains from his own wealth. Person i can transfer part of his wealth, t_i, to person j, such that $0\le t_i<w_i$. By $w_j>0$ we denote the pre-transfer wealth of person j. Following Bernheim and Stark (1988) and Stark (1999), we resort to a logarithmic representation of utilities, though our results are not contingent on this particular representation (refer to Remark 1 below). The utility of altruistic person i is then

$$u_i(w_i,w_j,t_i)=(1-\alpha_i)\ln(w_i-t_i)+\alpha_i\ln(w_j+t_i),$$

where $\ln(w_j+t_i)$ denotes the utility of person j.

As a first step, we seek to determine the optimal level of the transfer t_i. The derivative of $u_i(w_i,w_j,t_i)$ with respect to t_i is

$$\frac{\partial u_i(w_i,w_j,t_i)}{\partial t_i}=-\frac{1-\alpha_i}{w_i-t_i}+\frac{\alpha_i}{w_j+t_i}.$$

Then, $\frac{\partial u_i(w_i,w_j,t_i)}{\partial t_i}=0$ for $t_i=\bar{t}_i$, where $\bar{t}_i=\alpha_i w_i-(1-\alpha_i)w_j$. The assumption that it is not the case that the entire wealth of person i is transferred ($t_i<w_i$) is satisfied by $\bar{t}_i$ because $\bar{t}_i=\alpha_i w_i-(1-\alpha_i)w_j<\alpha_i w_i<w_i$. We also note that $\bar{t}_i>0$ if $\alpha_i>\frac{w_j}{w_i+w_j}\equiv\bar{\alpha}_i$. And because

$$\frac{\partial^2 u(w_i,w_j,t_i)}{\partial t_i^2}=-\frac{1-\alpha_i}{(w_i-t_i)^2}-\frac{\alpha_i}{(w_j+t_i)^2}<0,$$

the second order condition for a maximum of $u(\cdot)$ with respect to t_i holds. Thus, t_i^*, the optimal transfer that person i chooses to make to person j, where this transfer is treated as a function of α_i, is

$$t_i^*(\alpha_i)=\begin{cases}\alpha_i w_i-(1-\alpha_i)w_j & \text{if } \alpha_i>\frac{w_j}{w_i+w_j},\\ 0 & \text{otherwise,}\end{cases} \tag{1}$$

namely a transfer is made when the intensity of the altruistic feelings of person i is higher than the share of the wealth of person j in the aggregate wealth.

From (1) it follows that

$$\frac{dt_i^*(\alpha_i)}{d\alpha_i}=w_i+w_j>0 \tag{2}$$

for any $\alpha_i>\bar{\alpha}_i$, namely when the intensity of the altruistic feelings of person i is higher, the optimal transfer that this person makes is bigger. In addition, $\frac{dt_i^*(\alpha_i)}{dw_i}>0$, namely the optimal transfer responds positively to an increase in the altruistic person's own wealth; and $\frac{dt_i^*(\alpha_i)}{dw_j}<0$, namely the optimal transfer of the altruistic person responds negatively to an increase in the wealth of the beneficiary.

How does the inclination to resort to risk taking of a "practicing" altruist (a person who actively acts on his concern for the utility of another person by engaging in a transfer of wealth) respond to intensification of his altruistic feelings? On the one hand, a reward for successful risk taking will be amplified because such a realization will support an act of transfer that the intensification of altruistic feelings makes more desirable. On the other hand, the penalty for a failed risk taking will be amplified as well. In addition, we are also interested in finding out whether an altruistic person is more or less cautious than a non-altruistic person. Clearly, without additional analysis it will be hard to tell.

Following Pratt (1964) and Arrow (1965), the coefficient of relative risk aversion (RRA) of person i is defined as the negative of the wealth elasticity of person i's marginal utility, namely as

$$RRA_i\equiv-\frac{du_i'(w_i)}{u_i'(w_i)}\Big/\frac{dw_i}{w_i}=\frac{-w_i u_i''(w_i)}{u_i'(w_i)}.$$

In our setting[2]

$$RRA_i=-\frac{w_i\dfrac{\partial^2 u_i(w_i,w_j,t_i)}{\partial w_i^2}}{\dfrac{\partial u_i(w_i,w_j,t_i)}{\partial w_i}}=\frac{w_i\dfrac{1-\alpha_i}{(w_i-t_i)^2}}{\dfrac{1-\alpha_i}{w_i-t_i}}=\frac{w_i}{w_i-t_i}. \tag{3}$$

In order to investigate the relationship between the strength of the altruistic feelings of person i and his relative risk aversion, we utilize (1) to set $t=t_i^*(\alpha_i)$ in (4), and we treat RRA_i as a function of the parameter of α_i, namely we rewrite (3) as

$$\begin{aligned}RRA_i(\alpha_i)&=\frac{w_i}{w_i-t_i^*(\alpha_i)}=\frac{w_i}{w_i-\left[\alpha_i w_i-(1-\alpha_i)w_j\right]}\\&=\frac{1}{1-\alpha_i}\cdot\frac{w_i}{w_i+w_j}.\end{aligned} \tag{4}$$

We now formulate our first claim.

Claim 1. Under the condition that altruistic person i engages optimally in a wealth transfer to person j, namely under the condition that $\alpha_i>\bar{\alpha}_i$, then: (i) person i is more risk averse than a non-altruistic person; (ii) the higher is the intensity of person i's altruism, the greater is the risk aversion of person i.

Proof. To prove part (i) of the claim, we use (4) to obtain that the relative risk aversion of an altruistic person for whom $\alpha_i>\bar{\alpha}_i=\frac{w_j}{w_i+w_j}$ is

$$RRA_i(\alpha_i)=\frac{1}{1-\alpha_i}\cdot\frac{w_i}{w_i+w_j}>\frac{1}{\frac{w_i}{w_i+w_j}}\cdot\frac{w_i}{w_i+w_j}=1.$$

The utility function of a person who is not altruistic is $\hat{u}_i(w_i)=\ln(w_i)$. Denoting by $\widehat{RRA}_i$ the relative risk aversion of

[1] To the best of our knowledge, writings on altruism spanning from the collection of studies in Phelps (1975) to Bourlès et al. (2021) did not address these questions. When altruism and risk-taking behavior were linked, the context was the perception of the recipients of the altruistic transfers that altruism provides them with a form of insurance.

[2] In (3) we calculate the coefficient of relative risk aversion as a partial derivative with respect to w_i, the pre-transfer wealth that person i allocates at will. That is, we consider the coefficient as a (local) concavity measure of the utility function along the axis of the pre-transfer wealth argument, treating the level of the transfer as exogenous. This treatment enables us in Claim 1 to gauge the sensitivity of the coefficient of relative risk aversion to the intensity of person i's altruism. If, alternatively, we were to calculate the coefficient of relative risk aversion as a full derivative of the utility function with respect to w_i (including a dependence of t_i on w_i), then the sensitivity of the coefficient with respect to α_i would be nil, as the coefficient will be a function of only the pre-transfer wealth levels w_i and w_j. (A similar argument pertains to the case of person j, the beneficiary of an altruistic transfer, whose coefficient of relative risk aversion is defined in (5).)

this person, we get, quite obviously, that $\widehat{RRA}_i=1$. Because then $\widehat{RRA}_i<RRA_i(\alpha_i)$, we conclude that altruistic person i who engages optimally in a wealth transfer to person j is more risk averse than a comparable non-altruistic person.

To prove part (ii) of the claim, we obtain from (4) that

$$\frac{dRRA_i(\alpha_i)}{d\alpha_i}=\frac{1}{(1-\alpha_i)^2}\cdot\frac{w_i}{w_i+w_j}>0.$$

This concludes the proof of the claim. Q.E.D.

There are many good reasons to want to inculcate and instill altruism; altruistic transfers can contribute to social welfare by compensating for a variety of inequalities and misallocations. But in and of itself, the greater risk aversion of an altruistic person (as compared to the risk aversion of a person who is not altruistic) identified in this section might dissuade him from pursuing risky ventures which, if undertaken, could contribute to economic growth and social welfare.

3. The relative risk aversion of a beneficiary of an altruistic transfer

It is of interest to inquire whether our approach enables us to ascertain formally how the facility of an altruistic transfer influences the relative risk aversion of its beneficiary. We have shown that the optimal transfer by the altruistic person responds positively to a decrease in the wealth of the beneficiary. We have implicitly assumed that this decrease arises from an unforeseen external disturbance (a misfortune) that is out of the beneficiary's control ("a force majeure"). After all, a decline of the beneficiary's wealth that comes about from bad behavior such as the exertion of less intensive effort than is customary to form and preserve wealth (a moral hazard of sorts), if identified as such by the altruistic person, could erode the altruistic person's inclination to make a transfer. While this distinction is not without merit, it may not affect the sign of the change in the *global* relative risk aversion of the beneficiary if the altruistic person acts on the basis of an observed outcome (a realization) rather than on the basis of a (possibly unknown) reason of the outcome. The main point here is that the presence of an altruistic person can be conceived by the beneficiary as a form of insurance, even if partial. In such a setting, the beneficiary will be more willing to take actions that increase the variability of his wealth. And, as noted already by Arrow (1965), in the presence of partial insurance, overall willingness to take risks increases.[3]

Formally, for the beneficiary of an altruistic transfer whose utility function is $u_j(w_j,t_i)=\ln(w_j+t_i)$, the coefficient of RRA is

$$RRA_j=-\frac{w_j\dfrac{\partial^2u_j(w_j,t_i)}{\partial w_j^2}}{\dfrac{\partial u_j(w_j,t_i)}{\partial w_j}}=\frac{w_j\dfrac{1}{(w_j+t_i)^2}}{\dfrac{1}{w_j+t_i}}=\frac{w_j}{w_j+t_i}. \tag{5}$$

Similarly to what we did in formulating (4), we rewrite RRA_j for $t=t_i^*(\alpha_i)$ and we treat it as a function of the parameter α_i to obtain

$$RRA_j(\alpha_i)=\frac{w_j}{w_j+t_i^*(\alpha_i)}=\frac{1}{\alpha_i}\cdot\frac{w_j}{w_i+w_j}. \tag{6}$$

We now formulate our second claim.

[3] A telling example is in Stark (1993). A farmer in a developing country is reluctant to adopt an advanced new production technology - it is too much of a risk. This concern is overcome when a migrant family member whose income is independent of farming operations is present. The farmer's concern is mitigated because he reasons that if the adoption of the new technology goes sour, out of altruism the migrant family member will transfer (remit) part of his income to the farmer.

Claim 2. Under the condition that an altruistic person i engages optimally in a wealth transfer to person j, namely under the condition that $\alpha_i>\overline{\alpha}_i$, then: (i) person j is less risk averse than when not receiving a transfer; (ii) a higher intensity of person i's altruism results in a lower risk aversion of person j.

Proof. To prove part (i) of the claim, we note that in the case in which person j does not receive a transfer from person i, the utility of person j is $\hat{u}_j(w_j)=\ln(w_j)$, so that his relative risk aversion is $\widehat{RRA}_j=1$. When person j is in receipt of a transfer, which is equivalent to the assumption that $\alpha_i>\overline{\alpha}_i=\dfrac{w_j}{w_i+w_j}$, then from (6) we get that $RRA_j(\alpha_i)<1$. Therefore,

$$RRA_j(\alpha_i)<\widehat{RRA}_j.$$

Namely the relative risk aversion of the beneficiary of an altruistic transfer, here person j, is lower than the relative risk aversion of a comparable person who is not in receipt of an altruistic transfer.

To prove part (ii) of the claim, we obtain from (6) that

$$\frac{dRRA_j(\alpha_i)}{d\alpha_i}=-\frac{1}{\alpha_i^2}\cdot\frac{w_j}{w_i+w_j}<0.$$

This concludes the proof of the claim. Q.E.D.

Remark 1. The same results as the ones reported in Claims 1 and 2 can be obtained when the utilities from wealth are described by a function that is more general than the logarithmic function, specifically by the constant relative risk aversion (CRRA) utility function. To see this we express the utility of altruistic person i as

$$u_i(w_i,w_j,t_i)=(1-\alpha_i)\frac{(w_i-t_i)^{1-\eta}-1}{1-\eta}+\alpha_i\frac{(w_j+t_i)^{1-\eta}-1}{1-\eta},$$

where $\dfrac{(w_j+t_i)^{1-\eta}-1}{1-\eta}$ is the utility of person j, $\eta>0$, and $\eta\neq1$. (By application of L'Hopital's rule, when $\eta=1$ the CRRA utility function takes the form $u_i(w_i,w_j,t_i)=(1-\alpha_i)\ln(w_i-t_i)+\alpha_i\ln(w_j+t_i)$, which is the logarithmic specification that we started with.) Following steps that are similar to the steps taken in Section 2, the optimal transfer that person i chooses to make to person j is

$$t_i^*(\alpha_i)=\begin{cases}\dfrac{\alpha_i^{\frac{1}{\eta}}w_i-(1-\alpha_i)^{\frac{1}{\eta}}w_j}{\alpha_i^{\frac{1}{\eta}}+(1-\alpha_i)^{\frac{1}{\eta}}} & \text{if } \alpha_i>\dfrac{w_j^\eta}{w_i^\eta+w_j^\eta},\\ 0 & \text{otherwise,}\end{cases}$$

which implies that

$$\frac{dt_i^*(\alpha_i)}{d\alpha_i}=\frac{1}{\eta}\frac{\alpha_i^{\frac{1-\eta}{\eta}}(1-\alpha_i)^{\frac{1-\eta}{\eta}}}{\left[\alpha_i^{\frac{1}{\eta}}+(1-\alpha_i)^{\frac{1}{\eta}}\right]^2}(w_i+w_j)>0$$

for $\alpha_i>\dfrac{w_j^\eta}{w_i^\eta+w_j^\eta}$, namely when the intensity of the altruistic feelings of person i is higher, the optimal transfer that this person makes is bigger.

RRA_i as a function of α_i is

$$RRA_i(\alpha_i)=\eta\frac{w_i}{w_i-t_i^*(\alpha_i)}.$$

Because the utility function of a person who is not altruistic is $\hat{u}_i(w_i)=\dfrac{w_i^{1-\eta}-1}{1-\eta}$, and because the relative risk aversion of this person is $\widehat{RRA}_i=\eta$, it follows that an altruistic person who engages in a wealth transfer is more risk averse than a comparable non-altruistic person. In addition, the higher is the intensity of person i's altruism, the greater is the risk aversion of person i:

$$\frac{dRRA_i(\alpha_i)}{d\alpha_i}=\frac{dRRA_i(\alpha_i)}{dt_i^*(\alpha_i)}\frac{dt_i^*(\alpha_i)}{d\alpha_i}$$
$$=\eta\frac{w_i}{\left(w_i-t_i^*(\alpha_i)\right)^2}\frac{\alpha_i^{\frac{1-\eta}{\eta}}(1-\alpha_i)^{\frac{1-\eta}{\eta}}}{\left[\alpha_i^{\frac{1}{\eta}}+(1-\alpha_i)^{\frac{1}{\eta}}\right]^2\eta}(w_i+w_j)>0$$

for $\alpha_i>\frac{w_j^\eta}{w_i^\eta+w_j^\eta}$. By taking similar steps as the preceding ones, we can likewise replicate Claim 2.

Remark 2. The inferences obtained in this paper are not contingent on resorting to the relative risk aversion measure; using absolute risk aversion instead will yield the same inferences.

4. Conclusion

In concluding this paper we list three brief comments.

As is often the case, our analysis draws on several implicit assumptions. One such assumption is that the possibility that out of gratitude an altruistic transfer will induce a selfish beneficiary to become altruistic towards his benefactor was ruled out.

That we studied settings of two persons is not too limiting: the beneficiary of an altruistic transfer can be considered as a representative of a group, with sharing between the members of the group obeying some efficiency criteria. An interesting constellation that nonetheless will be worthy of further consideration is to disentangle the "group." A case in point is one in which the beneficiary j is altruistic not towards donor i as modeled in the Appendix, but towards Π people other than i. Suppose that at the outset person j is already engaged in making altruistic transfers to Π. When the intensity of person i's altruism towards person j intensifies, then not only as shown in Claim 2 there will be an effect on the relative risk aversion of person j; there can also be a chain effect on the relative risk aversion of Π.

We did not expand on the psychological or neurological channels that connect the making of an altruistic transfer with a reduced inclination to resort to risky behavior. There is some evidence that the act of an altruistic transfer relieves physical pain (Wang et al., 2020). If so, then it could be argued that people who experience a lesser pain are less inclined to resort to risky actions aimed at obtaining relief out of desperation, although the weight of this effect in the determination of the overall risk-taking behavior is unclear. In addition, a reduction of wealth as a consequence of an altruistic transfer could discourage risk-taking behavior directly, given the convention that, as wealth decreases, relative risk aversion increases. An intriguing conjecture is that both altruistic behavior and risk-taking behavior are affected by the same underlying factor. This possibility and the identification of that factor are worthy of follow-up study.

Appendix. Complementary analysis: The relative risk aversion of mutual altruists

Claims 1 and 2 presented, respectively, in Sections 2 and 3 identify opposite effects on the relative risk aversion of both the altruistic person and the beneficiary of an altruistic transfer. Therefore, qualitatively, the overall risk-taking behavior of a "population" that consists of an altruist and a beneficiary can be similar to the overall risk-taking behavior of a "population" devoid of altruism.

An intriguing issue that is difficult to track analytically is to ascertain the relative risk aversion of persons who, as modeled for example in Stark (1999, Chapter 1), are altruistic towards each other. What happens then to the relative risk aversion of these persons? In a population, here two people, who are mutually altruistic, will there be more or less risk-taking behavior than in a population of non-altruists? Will there be greater or lower relative risk aversion than in a population, here two people, in which only one person is an altruistic person?

Let there be two persons, i and j, who are altruistic towards each other, such that these persons' utility functions are

$$\begin{cases} u_i(w_i,w_j,t_i,t_j)=(1-\alpha_i)\ln(w_i-t_i+t_j)+\alpha_i\ln(w_j+t_i-t_j), \\ u_j(w_i,w_j,t_i,t_j)=(1-\alpha_j)\ln(w_j-t_j+t_i)+\alpha_j\ln(w_i+t_j-t_i), \end{cases} \tag{A1}$$

where $t_i\in[0,w_i]$ is the transfer that person i may make to person j; $t_j\in[0,w_j]$ is the transfer that person j may make to person i; α_i is the strength of the altruism of person i towards person j; and α_j is the strength of the altruism of person j towards person i.

For the setting of (A1) we can ask, in the way that we have inquired in Section 2, what are the optimal transfer amounts such that $\frac{\partial u_i(w_i,w_j,t_i,t_j)}{\partial t_i}=0$ and $\frac{\partial u_j(w_i,w_j,t_i,t_j)}{\partial t_j}=0$. It is straightforward to ascertain that these amounts are given by the set of equations

$$\begin{cases} t_i=\alpha_i w_i-(1-\alpha_i)w_j+t_j, \\ t_j=\alpha_j w_j-(1-\alpha_j)w_i+t_i. \end{cases}$$

An issue that arises here is that this set of equations cannot be solved. The difficulty stems from the fact that if any person increases his transfer by some amount, the other person will want to increase his transfer by the same amount and, therefore, an *interior* solution of this problem cannot be found. In such a circumstance, it is helpful to find out the boundary solutions that could be obtained. To simplify matters, we model the problem at hand as a sequential game. We assume that at the start of the game transfers are nil. Then, one after the other, the two persons announce the amounts of the transfers that they would like to make until a steady state is reached. By a steady state we mean a state in which no person wishes to modify the amount of his transfer. Without loss of generality, we assume that person i announces his intended transfer first. We characterize each pair of announcements as a period, denoting the periods by superscripts. For example, transfers occurring in the first period are denoted by t_i^1 and t_j^1. The persons are assumed to be "near-sighted" in the sense that a person bases his decision on the last transfer that was announced by the other person, without forming an expectation as to how the other person will behave in the future. In addition, we assume that transfers are made only after the steady state is reached; in the periods that precede the steady-state period, the persons merely announce their transfer intentions.

Similarly to Sections 2 and 3, we define the threshold levels for transfers to occur, $\overline{\alpha}_i\equiv\frac{w_j}{w_i+w_j}$ and $\overline{\alpha}_j\equiv\frac{w_i}{w_i+w_j}$, and we consider six cases. The cases are constructed on the basis of whether or not a person will make a positive transfer even if the other person does not make one, and of whether or not a person will make a positive transfer when the other person makes one.

(i) $\alpha_i\le\overline{\alpha}_i$ and $\alpha_j\le\overline{\alpha}_j$,
(ii) $\alpha_i>\overline{\alpha}_i$, $\alpha_j\le\overline{\alpha}_j$ and $\alpha_i+\alpha_j\le 1$,
(iii) $\alpha_i\le\overline{\alpha}_i$, $\alpha_j>\overline{\alpha}_j$ and $\alpha_i+\alpha_j\le 1$,
(iv) $\alpha_i>\overline{\alpha}_i$, $\alpha_j\le\overline{\alpha}_j$ and $\alpha_i+\alpha_j>1$,
(v) $\alpha_i\le\overline{\alpha}_i$, $\alpha_j>\overline{\alpha}_j$ and $\alpha_i+\alpha_j>1$,
(vi) $\alpha_i>\overline{\alpha}_i$ and $\alpha_j>\overline{\alpha}_j$.

In case (i), in the first period $t_i^1=0$ and $t_j^1=0$. In the second period the persons do not have an incentive to announce different transfers than in the first period, $t_i^2=0$ and $t_j^2=0$, so therefore, a steady state is reached.

In case (ii), $t_i^1=\alpha_i w_i-(1-\alpha_i)w_j>0$. Taking this into account, person j's optimal transfer is $\alpha_j w_j-(1-\alpha_j)w_i+\alpha_i w_i-(1-\alpha_i)w_j=(\alpha_i+\alpha_j-1)(w_i+w_j)\leq 0$. The inequality here holds because in this case $\alpha_i+\alpha_j\leq 1$. Thus, person j announces a transfer of $t_j^1=0$, and a steady state is reached.

Case (iii) is the reverse of case (ii), with the difference that in case (iii) at the steady state, person j will make a positive transfer $t_j^1=\alpha_j w_j-(1-\alpha_j)w_i>0$, whereas person i will make no transfer, $t_i^1=0$.

In case (iv), $t_i^1=\alpha_i w_i-(1-\alpha_i)w_j>0$, and $t_j^1=(\alpha_i+\alpha_j-1)(w_i+w_j)>0$. Because both transfers are positive, a steady state is not reached, and the persons will continue to "outbid" each other, namely in period k $t_i^k=\alpha_i w_i-(1-\alpha_i)w_j+t_j^{k-1}$ and $t_j^k=\alpha_j w_j-(1-\alpha_j)w_i+t_i^k$. This process will continue up until such time that one of the persons runs out of wealth, being driven into a corner, so to speak.[4] Without loss of generality, we can assume that the wealth levels are such that $w_i>w_j$, and that in period k, $t_i^k=\alpha_i w_i-(1-\alpha_i)w_j+t_j^{k-1}<w_i$, but $\alpha_j w_j-(1-\alpha_j)w_i+t_i^k>w_j$. Thus, the transfer amount announced by person j is actually $t_j^k=w_j$. Then, in the subsequent period $k+1$, $t_i^{k+1}=\alpha_i w_i-(1-\alpha_i)w_j+w_j$ and $t_j^{k+1}=w_j$, which constitute a steady state.

It is easy to verify that cases (v) and (vi) yield steady states that are the same as the steady state obtained in case (iv).

In essence, the net transfers received (t_j-t_i in the case of person i, and t_i-t_j in the case of person j) when there are two altruistic persons are not much different from the transfer that occurs when there is only one altruistic person. For example, in case (iv), the net transfer t_j-t_i is negative, meaning that person i is the benefactor, transferring the amount $\alpha_i w_i-(1-\alpha_i)w_j$ to person j. Thus, the outcome in case (iv) is the same as the outcome reported in Section 2.

In sum, the effects of the altruistic trait on relative risk aversion in the case of two persons who are altruistic towards each other is analogous to the effects presented in Sections 2 and 3. The main difference between the situation studied in this Appendix and the one in Sections 2 and 3 is that which person will be the beneficiary of a transfer (will receive a positive net transfer) depends on the relative intensities of the altruism of the two persons, and on their relative levels of wealth. Specifically, the person who makes a net transfer will behave as the benefactor in Section 2, and his relative risk aversion will be higher. On the other hand, the person who is a beneficiary of a positive net transfer will behave as the beneficiary in Section 3, and his relative risk aversion will be lowered. Once again, qualitatively speaking, the overall risk-taking behavior of "a population," here two people, that consists of mutual altruists can be similar to the overall risk-taking behavior of "a population," here two people, of no altruists.

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[4] The process described does not contradict the assumption made in Section 2 that a person's optimal transfer is lower than the person's wealth. Even though the wealth of person j is w_j, the transfer announcement made by him is conditional on receiving a transfer t_i^k from individual i. Therefore, the wealth out of which individual j contemplates making a transfer is $w_j+t_i^k$, and this wealth is larger than the transfer w_j that he announces.