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The Price of a Price

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The Price of a Price:
On the Crowding Out of Social Norms

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Abstract

There is increasing empirical and experimental evidence that providing financial incentives to agents to perform certain socially desirable actions may permanently reduce other types of motivations to undertake these actions. We study the impact of financial incentives on the desire for social approval, using the example of blood donation. We show that in a society with altruists and egoists, who all care about social approval, introducing a payment into a voluntary system may actually decrease the amount of blood donated. Withdrawing the financial incentive does not restore the norm to donate and may reduce the supply of blood even further.

Keywords: social norms, intrinsic and extrinsic motivation, network effects, health policy

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1. Introduction

According to most economic theory, if people are willing to make effort even if they are not financially compensated, they will work even more eagerly if they get paid. The underlying assumption is that an existing non-financial motivation is unaffected when a financial reward is introduced, hence, different kinds of financial and non-financial motivations can be added up. This assumption allows economists to treat the issue of non-financial incentives as being a matter of exogenous personal preferences, which cannot be affected by economic policies. In this way economics is able to reduce the problem of motivating people to designing optimal financial compensation schemes.

This approach aroused occasional discomfort among some representatives of the economic profession, who argued that *homo economicus* and *homo sociologicus* cannot be so easily separated. People are usually motivated by a combination of forces, which may reinforce or weaken one another. One of the first arguments against a careless use of basing government policies on economic incentives alone was provided by Richard Titmuss (1972). After comparing the American (mostly paid or providing other benefits) and British (entirely voluntary and unpaid) systems of obtaining blood for medical purposes, he concluded that the paid system results in shortages and a lower quality of blood supply. He also noticed that the social characteristics of donors in Britain differed from the characteristics of blood donors in the US. In Britain they were representative of the population, while in America they tended to have lower income, lower education and often belonged to ethnic minorities. His conclusion was that paying for blood destroys an altruistic motivation to donate. Moreover, he claimed that this motivation is destroyed permanently, and that removing the monetary incentive would not restore the altruistic motivation, at least not soon.

In recent years, many experiments[1] have been conducted demonstrating the importance of rethinking the interaction between different types of motivation. Among other things, it has been observed that monetary incentives can "crowd out" other sorts of motivation, often called "intrinsic" motivation. Once crowded out, the

[1] For an overview of psychological literature on this subject, see Deci, 1999; for descriptions of economic experiments see e.g. Frey, (1997, 1999), Fehr (2000) and Gneezy and Rustichini (2000).

“intrinsic” motivation often does not come back after the monetary incentive has been removed.

A study of crowding out of intrinsic motivation encounters a problem with defining what the term really includes. The literature suggests such factors as the joy of having control and self-determination, self-confidence, social status and appreciation by others. (see e.g. Deci, 1999, and Frey, 1997, 1999). Some of them are in fact “extrinsic” non-monetary incentives. Some of them may be crowded out, others not affected or even “crowded in” by financial incentives. It therefore seems justified to identify different sources of non-financial incentives and study the interaction between financial incentives and each of the others separately.

In this paper we want to interpret the above mentioned experimental results and the findings of Titmuss by analyzing one of the possible mechanisms underlying the interaction of financial and non-financial motivations. We analyze a situation in which some people’s actions are driven by the desire of social approval or status, which we label “social reward”.[2] Introducing financial incentives may eliminate or reduce the source of status, thereby reducing that type of motivation. We study the influence of financial rewards on social rewards and on actions which are significantly influenced by the presence or absence of social rewards. Our leading example will be blood supply. Later on we will comment on the extent to which our conclusions are relevant in other cases.

We analyze the interaction between financial and non-financial motivations and the resulting implications of introducing payment for blood donation by means of a simple model. There are two types of individuals in the population: altruists and egoists.[3] Both types are motivated to the same extent by extrinsic social reward and donating blood also involves the same cost to both types of people. In addition, egoists are motivated by money and altruists by an intrinsic desire to help others. Hence, an egoist will not rationally supply blood unless the sum of social and financial reward compensates them for the cost. Altruists, on the other hand, will rationally donate if the sum of social and intrinsic rewards exceeds the cost. The

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[2] One source of social status is adherence to a social norm. The social reward may depend only on adherence to the norm, (as in, e.g. Akerlof, 1980, 1982) but it may also depend, for instance, on the (opportunity) cost that an individual has to incur to follow the norm, (as in Dufwenberg and Lundholm, 1998), or on the number of other people who adhere to the norm (as in Lindbeck, Nyberg and Weibull, 1999).

[3] A justification for the existence of egoists and altruists in the population can be found in the evolutionary game theory literature, see also Frank (1987).

source of social reward is belonging to a large group that follows a social norm, and being recognized as such. The social norm is "donate blood for (at least partially) altruistic reasons". Consequently, two factors make up the social reward. The first factor is the likelihood of being recognized as a person driven by altruistic motivation. We assume that on noticing a donor people do not know her motivation, but they know the proportion of altruists in the population of donors and take this proportion as an estimate of the probability that she is an altruist. The second factor is the number of people that also follow the norm for altruistic reasons. The idea here is that a norm is only a norm if it is followed by enough people, since social approval is expressed mainly by those individuals who donate blood themselves. Hence, the social reward from donating is larger if more altruists donate. As a consequence, altruistic donors create positive network externalities for two reasons: because they create the norm and because they make it more likely that a donor is regarded as a person who follows the social norm to donate. On the other hand, egoistic donors create a negative externality as they make it less likely that another donor is recognized as an altruist.

Following the literature on evolutionary game theory,[4] we assume that for most part people make the decision whether or not to supply blood on a rational basis, i.e., given their utility function and the number of altruistic and egoistic donors at a particular moment, each agent decides whether or not donating gives a higher utility than not donating. However, at each moment there is also a small chance that people decide against their own interest. Using this framework of evolutionary game theory, we are able to make a distinction between medium-run and long-run equilibria. In the medium run, the dynamics of the system is driven by the rational decisions of individual agents. If two equilibria exist, any of them may emerge in the medium run, depending on the initial state. In the (ultra) long run, the fact that people sometimes behave irrationally matters. In general (even if there are multiple medium-run equilibria), there is a unique equilibrium that prevails in the long run and this is the equilibrium that is *stochastically stable*. Roughly speaking, an equilibrium is stochastically stable if it requires agents to make more irrational moves to let the rational dynamics drive the system to another equilibrium than any other equilibrium.

By means of this model we obtain the following main results:

[4] For an Introduction, see for example, Samuelson (1998), Young (1998) or the motivating examples in Kandori, Malaith and Rob (1993) and Young (1993).

- In the absence of financial incentives, and under some additional restrictions on the parameters, the long-run equilibrium involves all altruists to donate blood and no egoists.
- Providing financial incentives to increase blood supply may have adverse effects in the medium run when, as a result, the social norm to donate is destroyed.
- Even if introducing a financial reward leads to an increase of blood supply in the short and medium run, it may have adverse effects in the long run.
- Even if introducing a financial reward does not have adverse effect on the total blood supply, it may make obtaining blood much more costly, if the price has to compensate for the crowded out social norm.
- Once a norm has been crowded out, it takes a long time to rebuild it. A norm can be destroyed slowly or quickly, but only slowly restored.

Below, we will briefly explain the main intuition for these findings. We start at the situation when no financial reward is being offered for donating blood. We are especially interested in an intermediate situation when the intrinsic motivation alone is not enough to encourage altruists to donate and the maximum social reward is not enough for egoists to supply blood. In this case, there may be two types of medium-run equilibria. Either all altruists donate, or none. In the first case, a large number of donors makes sure that the social norm "donate blood altruistically" exists, and together with the intrinsic motivation the social reward is high enough to outweigh the cost of donating. In the second case, no one donates blood, and as a consequence there is no social norm to donate. It turns out that the equilibrium with a social norm to donate is stochastically stable if the cost of donating blood is relatively small and the intrinsic altruistic motivation and the potential social reward are relatively high. Hence, if no financial incentive is offered for a long enough time, all altruists will donate blood.

Given this starting position in which all altruists donate, we study the effect of introducing a financial reward for donating blood (possibly with the intention to stimulate blood donation). If the price for donating is high enough, this will induce egoists to sell blood. As a result the proportion of altruists in the total population of blood donors will decrease and it will be more difficult to recognize donors. The altruists' utility of donating blood will decrease. If the social reward will decrease enough, altruists will stop donating and the social reward will fall to zero. This is the crowding-out effect. Depending on the price, two situations can occur in the medium run. If the price is lower than the cost of donating, egoists will also stop donating in the medium run. As a result, the supply of blood will fall to zero. If the financial incentive is larger than the cost of donating, egoists will continue to supply. In this case, introducing a financial reward leads to crowding out of the social norm and the population of blood donors changes, from mainly altruistic to purely egoistic. The total supply of blood may be larger or lower, depending on the relative numbers of altruists and egoists in the whole population.

Hence, if a social norm disappears in the medium run, the total blood supply may decrease (and even fall to zero) or increase. In all cases, however, obtaining blood becomes more expensive for society in comparison to the voluntary system.

Even if the altruists will not stop donating in the medium run, i.e., when the social reward will not decrease very much and the medium-run supply increases, blood supply may actually decrease in the long run. This happens when the equilibrium with donors loses its stochastic stability property after a financial reward has been introduced.

Finally, we analyze what happens if the reward is withdrawn, possibly because the health authorities have realized that the measure had adverse effects. Then, some or all egoists may stop donating. When the social norm had already been crowded out the equilibrium without donors results in the medium run. If the equilibrium with donors is stochastically stable in the absence of a financial reward, the social norm will eventually be rebuilt, but it may take a very long time.

On blood donation, Stewart (1992) presents a model, where people have a choice between donating and selling blood. Some donors, called believers, believe that blood should be donated, others get utility from following a norm which is also followed by others. Introducing a financial reward increases the utility of selling blood as compared to donating, which decreases the amount of donated blood and increases that of sold blood. This increases the blood supply in the short-run, but in the long run there will be fewer believers and the blood supply may decrease. Hence, in Stewart's model the crowding out occurs through a change in the numbers of "altruists" (believers) and "egoists" (non-believers). In a different context, Bar–Gill and Fershtman (2000) conclude that financial incentives may change preferences and actually lead to a lower provision of a public good. The main difference in implications between these models and ours is that in the above mentioned papers removing the financial reward would change the distribution of types or preferences back and restore the social norm in the same amount of time as it took to destroy the norm. In our paper, in contrast, preferences remain unchanged, and destroying a social norm happens much faster than its rebuilding.

Although blood donation is our leading example, we think the analysis applies more broadly to cases where economic and social incentives interact, as the influence of financial incentives on volunteer work, or on the voluntary provision of public goods. The analysis may also be used to provide an explanation of the results of a field study conducted in a group of day-care centers in Israel (Gneezy and Rustichini, 2000). Their study reports that some parents arrived late to collect their children. After introducing a monetary fine for late-coming parents, more parents began to come late. Removing the fine did not restore the initial situation. It is clear that the type of phenomena they describe fit nicely the main points we make in the present paper.

The rest of the paper is organized as follows. Section 2 introduces the model. Section 3 analyzes the type of equilibria that may arise under a voluntary blood donation system. Conditions are stated under which a social norm to donate will emerge as a stochastically stable equilibrium in the long run. Section 4 studies the effects of introducing a financial reward. In Section 5 we examine the consequences of removing the financial reward. Section 6 concludes.

2. The Model

Our society consists of two types of people, which we simply call (for easy reference) altruists and egoists. The total number of each type is denoted by $\overline{N}_a$ and $\overline{N}_e$, respectively, and N_a^t and N_e^t denote the number of individuals of each type who supply blood in period *t.* An individual decides only whether to donate blood or not, and then gives a pre-specified quantity, which is the same for everyone. The utility from not donating blood is normalized to zero. The utilities from donating blood are

$$\begin{aligned} u_a^t &= a + s^t - c \qquad \text{for altruists} \\ u_e^t &= p + s^t - c \qquad \text{for egoists} \end{aligned} \tag{1}$$

When donating blood, both types value the social reward s similarly, and they incur the same cost c. The difference between types lies in the third component of the utility function: altruists have an intrinsic motivation to donate, a, while egoists enjoy earning money, p. For simplicity, it is assumed that altruists do not care about money at all, and that egoists do not have any intrinsic motivation.

The social reward function is given by the following expression:

$$s^t = \frac{\beta N_a^t}{N_a^t + N_e^t} N_a^t, \quad s^t = 0 \ \text{ if } \ N_e^t = 0 \text{ and } N_a^t = 0,\text{[5]} \tag{2}$$

where β is some positive parameter. As explained in the Introduction, social reward depends on the probability that a particular blood donor is an altruist, given by $N_a^t / (N_a^t + N_e^t)$, and on the number of people donating for altruistic reasons, N_a^t.

In order to be able to study the dynamics of social change, we assume that in each period some altruists and egoists decide whether to donate blood or not. The decisions are made on the basis of the utility from donating blood in the previous period: if it is larger than zero, more people will rationally decide to donate. We assume therefore the following rules for the dynamics of N_i^t, $i = a, e$:

$$\begin{aligned} &\text{If } u_i^t > 0 \text{ and } N_i^t < \overline{N}_i, \text{ then } N_i^{t+1} > N_i^t; \\ &\text{If } u_i^t < 0 \text{ and } N_i^t > 0, \text{ then } N_i^{t+1} < N_i^t; \\ &\text{Otherwise } N_i^t \text{ does not change.} \end{aligned} \tag{3}$$

We determine the equilibrium size and composition of the blood-donating group. The equilibrium number of egoistic and altruistic donors is denoted by N_e and N_a, respectively. Given the rules of motion, an equilibrium N_i is reached when $u_i^t = 0$, $i = e, a$, or $u_i^t > 0$ and $N_i = \overline{N}_i$, or $u_i^t < 0$ and $N_i = 0$.

[5] Note that the social reward function is continuous as $\lim_{N_a \to 0} N_a^2 / (N_a + N_e) = 0$, and $\lim_{N_e \to 0} N_a^2 / (N_a + N_e) = N_a$, which equals 0 if $N_a = 0$.

The rules of motion discussed above are based on the assumption that individuals act rationally, always choosing the action that gives them higher utility. As explained in the Introduction, we assume that with a small probability ϵ agents make mistakes and choose the "wrong" action, that is donate when they should not, or vice versa. This implies that the rules of motion are stochastic: for instance, when the altruists' utility from donating is positive, it is most likely that the number of altruistic donors will increase, but there is a small probability that it will actually decrease or stay unchanged.

Given the stochastic rules of motion, there is a positive probability of reaching any of the equilibria. If the probability of making mistakes is small enough, however, the short-run dynamics of the system will be governed almost surely by the deterministic part specified above. The equilibrium that arises as a result of this short-run dynamics is termed the medium-run equilibrium. If there is a unique medium-run equilibrium, this will also be the long-run equilibrium. For some parameter values, more medium-run equilibria exist. Which one of them will prevail depends on the initial state. The set of initial states from which the system converges in the medium run to a certain equilibrium with probability one constitutes the *basin of attraction* of that equilibrium.

In the long run, however, it is not the initial state of the system that determines which equilibrium is the most likely one to emerge. Rather, the possibility of making a mistake implies that in the long run the system will spend most of the time in the equilibrium that is stochastically stable. To determine which of the equilibria is stochastically stable, we can use the following method (cf., Kandori, Mailath, Rob (1993) and Young (1993)): we compare the minimum number of errors that individuals have to make in order to move out of the basin of attraction of the equilibria. The equilibrium that requires most mistakes to be made, is the one that is most difficult to upset and, therefore, is stochastically stable.

3. Voluntary blood donation

Our analysis starts with the situation in which no financial rewards are provided. Hence, only intrinsic motivation and social reward play a role. In this case, the utilities of both types are given by

$$u_a^t = a + \beta (N_a^t)^2 / (N_a^t + N_e^t) - c$$
$$u_e^t = \beta (N_a^t)^2 / (N_a^t + N_e^t) - c \qquad (4)$$

We begin with the medium-run analysis and focus on the deterministic dynamics given by (3). Depending on parameter values and initial states, a variety of equilibria can arise. Results 1, 2 and 3 describe the possible equilibrium configurations.

Result 1. If $p = 0$ and $c < a$, a unique equilibrium exists, which is given by

$N_a = \overline{N}_a$, and

i) $N_e = \overline{N}_e$ if $c < \beta(\overline{N}_a)^2 / (\overline{N}_a + \overline{N}_a)$

ii) $N_e = \beta \overline{N}_a^2 / c - \overline{N}_a$ if $\beta(\overline{N}_a)^2 / (\overline{N}_a + \overline{N}_e) < c < \beta \overline{N}_a$

iii) $N_e = 0$ if $c > \beta \overline{N}_a$

Proof: If $c < a$, altruists always get positive utility from donating blood so that $N_a = \overline{N}_a$. Given this, three different situations can arise:

i) If $c < \beta \overline{N}_a^2 / (\overline{N}_a + \overline{N}_a)$, the egoists' utility from donating is positive for each $N_e^t \leq \overline{N}_e$. Hence, in equilibrium $N_e = \overline{N}_e$.

ii) If $\beta(\overline{N}_a)^2 / (\overline{N}_a + \overline{N}_e) < c < \beta \overline{N}_e$, an egoist gets positive utility from donating if $N_e^t = 0$, but a negative utility if $N_e = \overline{N}_e$. It follows that in the equilibrium $0 < N_e < \overline{N}_e$. Moreover, in equilibrium egoists must be indifferent between donating and not, which yields $N_e = \beta \overline{N}_a^2 / c - \overline{N}_a$.

iii) If $c > \beta \overline{N}_a$, an egoist gets negative utility from donating even if the social reward is maximal. Hence, $N_e = 0$. ///

Result 1 can be interpreted as follows. If intrinsic motivation is larger than the cost of donating, an altruist will donate no matter what other altruists or egoists do. The social reward only matters for egoists: if altruists provide enough positive externalities, egoists will be willing to donate in order to get social appreciation. However, by joining the donors, they create negative externalities for other egoists.

Depending on how large the positive and negative externalities are in comparison to costs, three equilibria are possible: with all, some and no egoists donating.

Result 2. If $p = 0$ and $c > a + \beta\overline{N}_a$, a unique equilibrium exists with $N_a = N_e = 0$.

Proof. If $c > a + \beta\overline{N}_a$, altruists get a negative utility from donating even if the social reward is maximal. Hence, in any equilibrium $N_a = 0$. When $N_a = 0$, there is no social reward, and the utility of egoists from donating is –*c*. Hence, $N_e = 0$. ///

Result 2 says that when costs of donating are larger than the maximal satisfaction that altruists can get, no altruist will ever donate. Since without any altruist donating the social reward from donating is zero, egoists will not donate either.

Result 3. If $p = 0$ and $a < c < a + \beta\overline{N}_a$, three kinds of equilibria exist:

(i) $N_a = N_e = 0$;

(ii) $N_a = (c-a)/\beta$ and $N_e = 0$

(iii) $N_a = \overline{N}_a$, and

$N_e = \overline{N}_e$	if	$c < \beta(\overline{N}_a)^2/(\overline{N}_a + \overline{N}_a)$
$N_e = \beta\overline{N}_a^2/c - \overline{N}_a$	if	$\beta(\overline{N}_a)^2/(\overline{N}_a + \overline{N}_e) < c < \beta\overline{N}_a$
$N_e = 0$	if	$c > \beta\overline{N}_a$

Proof. In equilibrium, either $N_a = 0$, $N_a = \overline{N}_a$ or $0 < N_a < \overline{N}_a$ and $u_a = 0$. We consider these three possibilities in turn.

(i) If $N_a = 0$, $u_e < u_a < 0$ since $a < c$ and we must have that $N_e = 0$. It is easy to see that $N_a = N_e = 0$ is an equilibrium.

(ii) Suppose that $0 < N_a < \overline{N}_a$ and $u_a = 0$. Since $u_e^t < u_a^t$ for any N_a^t and N_e^t, $u_a = 0$ implies that $u_e < 0$. Hence, the only possible equilibrium situation is where $N_e = 0$. Then, $u_a = a + \beta N_a - c = 0$ and $u_a = (c-a)/\beta$.

(iii) If $N_a = \overline{N}_a$, three values of N_e can arise, depending on the parameter values (see the proof of Result 1). It still remains to be shown that when N_e takes these values, $u_a > 0$ (which is necessary condition for the "all altruists donate" equilibrium

to be stable). The three possible cases are $N_e = \overline{N}_e$, $u_e = 0$, or $N_e = 0$. In the first two cases $u_e \geq 0$, which implies $u_a > 0$. When $N_e = 0$, then $u_a = a + \beta\overline{N}_a - c$, which is larger than 0 since, by assumption, $c < a + \beta\overline{N}_a$. ///

In the situation described in Result 3 intrinsic motivation alone is not enough to induce altruists to donate. However, if enough social reward is added, i.e., if enough altruists donate, it may individually become worthwhile to donate. Accordingly, three equilibria are possible: one in which no one donates, one in which some altruists and no egoists donate and in which altruists are indifferent between donating or not, and one in which all altruists donate. If all altruists donate, the number of egoistic donors depends on the social reward in that case compared to the cost of donating.

In the medium run, where the agents act always rationally and the dynamics is deterministic, the outcome depends on the initial state. The dynamics for the more interesting case in which $a < c < a + \beta\overline{N}_a$ is illustrated in figures 1*a*, 1*b* and 1*c* for three different ranges of parameter values.

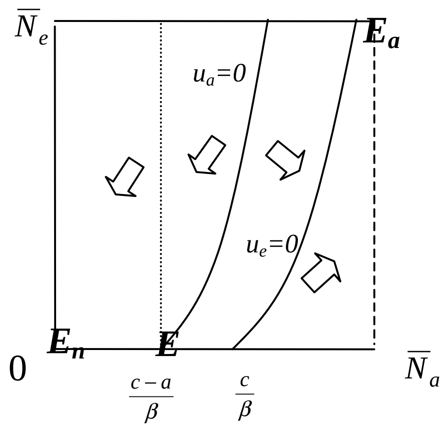

Figure 1*a*: Medium – run dynamics for
$c < \beta\overline{N}_a^2 / \overline{N}_a + \overline{N}_e$

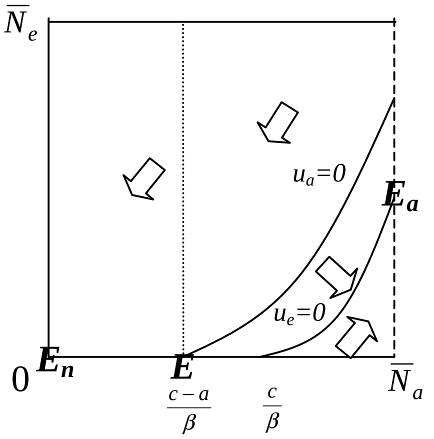

Figure *1b*: Medium-run dynamics for $\beta \overline{N}_a^2 / \overline{N}_a + \overline{N}_e < c < \beta \overline{N}_a$

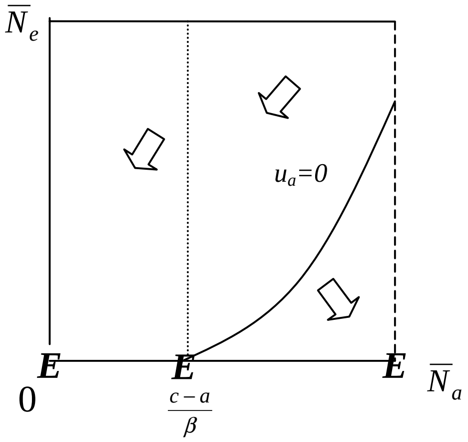

Figure *1c:* Medium –run dynamics for $c > \beta \overline{N}_a$

The horizontal and vertical axes show the number of altruistic and egoistic donors, respectively, ranging from *0* to their total numbers in the whole population. $\boldsymbol{E_a}$, $\boldsymbol{E_s}$ and $\boldsymbol{E_n}$ denote equilibria with all, some and no altruists donating, respectively. The indifference curves, $u_a = 0$ and $u_e = 0$, show the combinations of N_a^t and N_e^t at which altruists and egoists, respectively, are indifferent between donating or not. The utility of altruists from donating is positive to the right of the altruists' indifference curve, and negative to the left of it. Hence, according to the rules of motion, N_a^t is increasing to the right, and decreasing to the left of the curve. This follows from the positive network externalities generated by altruists, which cause a critical mass effect: when the number of altruists exceeds a certain critical mass, all other altruists are attracted. On the other hand, the utility of egoists is positive below the egoists' indifference curve, and negative above. Hence, N_e^t is typically converging to an interior equilibrium value. This is caused by the negative network effect: the more egoists donate, the less worthwhile it becomes for other egoists to donate as well. The dynamics of N_a^t and N_e^t is illustrated by arrows. As $a < c < a + \beta \overline{N}_a$ in all three figures, three equilibria exist. In figure *1c,* $u_e < 0$ for all combinations of N_a^t and N_e^t, which is why the egoists' indifference curve do not show up. We can immediately see that the equilibrium with only some altruists donating is unstable: the system only arrives there with certainty if it is also the starting point.

When the society is initially to the right of the altruists' indifference curve, it will move in the medium run almost surely towards the equilibrium with all altruists donating. Hence, this area is the basin of attraction of that equilibrium. Similarly, the area to the left of the dotted line $N_a = (c-a)/\beta$ is the basin of attraction of the equilibrium with no donors. For these initial states the number of altruistic donors is too small to attract other altruists, so that eventually all altruists will stop donating. Finally, if the society starts in the area to the right of the dotted line but to the left of the altruists' indifference curve, it may end up in any of the three equilibria. In that area both altruists and egoists stop donating, but the final result will depend on details of the dynamic process which we have not specified in our general formulation in (3).

Hence, in the medium-run, deterministic dynamics, the outcome depends on the initial state. To find the outcomes in the long run, we use the criterion of the evolutionary game theory. The evolutionary argument states that in the long run people are likely to make occasional mistakes and act against their interests. Then, all equilibria have a positive probability of arising, because the system can move from one basin of attraction to another after a sufficient number of mistakes. However, some equilibria are more likely to arise than others, and the most likely ones are described as stochastically stable.

As described in Section 2, a stochastically stable equilibrium is the equilibrium where the minimum number of errors that individuals have to make in order to move out of the basin of attraction is largest. Note first that the equilibrium with only some altruists donating is generically unstable, as one mistake in any direction will push the system out of it.[6] To determine the minimum number of mistakes for the remaining two equilibria, let us first consider the equilibrium with no donors. It is clear from the figure that the closest point on the boundary of the basin of attraction is the point $((c-a)/\beta, 0)$. Hence, $(c-a)/\beta$ altruists (or, more precisely, the smallest integer larger than that) have to start donating to get out of the basin of attraction of the equilibrium with no donors.

To determine the minimal number of mistakes needed to get out of the basin of attraction of the equilibrium with all altruists donating we first need to find a point on the boundary of the basin of attraction which can be reached with the smallest number of errors. In the proof of Proposition 1, we show that the boundary can be reached with the minimum number of errors if only altruists make mistakes in their actions.

[6] We do not consider the special case where $(c-a)/\beta = 1$.

Using that result, the proposition states conditions under which the equilibrium with donors is stochastically stable.

Let $I\,[x]$ denote the smallest integer larger or equal *x*.

Proposition 1. The equilibrium in which $N_a = \overline{N}_a$ is stochastically stable, if

$$I\left[\overline{N}_a - \frac{c-a+\sqrt{(c-a)^2+4(c-a)N_e}}{2\beta}\right] > I\left[\frac{c-a}{\beta}\right].$$

Proof. We first find the shortest way (requiring the least mistakes) from $\boldsymbol{E_a}$ to $\boldsymbol{E_n}$, ignoring for the moment the integer problem. Note that the boundary of the basin of attraction of $\boldsymbol{E_a}$ = $(\overline{N}_a, N_e)$ is given by the indifference curve $u_a = 0$. Hence, we have to find a point (N_a^t, N_e^t) on this indifference curve such that the sum of vertical and horizontal distance from that point to the equilibrium is minimal:

$$\min \overline{N}_a - N_a^t + \left|N_e^t - N_e\right| \quad \text{s.t. } N_e^t = \frac{\beta(N_a^t)^2}{c-a} - N_a^t .$$

Let $\hat{N}_a, \hat{N}_e$ denote the solution to this problem. Note first that as the indifference curve is upward sloping $\hat{N}_e < N_e$ cannot be a solution as it would require more errors of both types than when $\hat{N}_e = N_e$. Hence, $\hat{N}_e \geq N_e$. Thus, the problem becomes

$$\min_{N_a^t} \; \overline{N}_a - N_e^t - 2N_a^t + \frac{\beta(N_a^t)^2}{c-a} \text{ s.t. } N_e^t \geq N_e .$$

It is easy to see that the derivative is positive if, and only if, $N_a^t > (c-a)/\beta$. At $\hat{N}_a = (c-a)/\beta$, $\hat{N}_e = 0$, which does not satisfy the constraint $\hat{N}_e \geq N_e$ for $N_e > 0$. Hence, we must have that the constraint is always binding so that $\hat{N}_e = N_e$ and

$$\hat{N}_a = \frac{c-a+\sqrt{(c-a)^2+4(c-a)N_e}}{2\beta} .$$

As the smallest number of mistakes to get out of the basin of attraction of $\boldsymbol{E_n}$ is the smallest integer larger or equal $(c-a)/\beta$, the statement of the Proposition follows.

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It can be seen from Proposition 1 that the equilibrium with all altruists donating is stable if the total number of altruists is large, the cost of donating is low, the total number of egoists is small, and people care a lot about social reward. Moreover, if in the equilibrium with all altruists as donors many egoists donate, this equilibrium is less likely to be stochastically stable. The reason is that egoistic donors make the altruists' utility from donating lower. Then, when even only a few altruists do not donate by mistake, the resulting decrease in the social reward may be enough to bring other altruists' utility from donating below zero. That can also be seen in figures: the higher the equilibrium value N_e, the shorter the distance to the boundary of the basin of attraction.

In the rest of the paper we will concentrate on the more interesting case where the parameters values are such that two equilibria exist and the "many donors" equilibrium is stochastically stable. In this case a financial reward may crowd out the social norm to donate. In other cases the outcomes are more obvious and less interesting. A unique equilibrium with all altruists donating exists only when the intrinsic motivation of altruists is sufficient to induce their donations. Hence, the social norm is not necessary to secure donations. On the other hand, if there is only a unique equilibrium without donors, or if there are two equilibria, but in the long run the equilibrium without donors arises, a social norm to donate is not developed, and hence it cannot be crowded out. Thus, we concentrate on a case when a social norm arises and is necessary to attract donors.

4. Introducing a financial reward

In this section we study the effect of introducing a financial reward into the situation analyzed in the previous section, i.e., from now on we assume that $p > 0$. We consider the parameter values for which two equilibria exist when no compensation is offered, and the equilibrium with donors is stochastically stable. This will be the initial situation in this section at the moment of a financial reward is introduced.

When a positive price is introduced, the utility functions are given by

$$u_a^t = a + \frac{\beta(N_a^t)^2}{N_a^t + N_e^t} - c$$

$$u_e^t = p + \frac{\beta(N_a^t)^2}{N_a^t + N_e^t} - c$$

We consider first the medium-run dynamics, where all agents behave rationally and always act according to their utilities. Results 4 and 5 describe the new medium-run equilibria, for two ranges of parameter values.

Result 4. Suppose that $a < c < a + \beta\overline{N}_a^2 / (\overline{N}_a + \overline{N}_e)$. Then, when a $p > 0$ is introduced, the new medium-run equilibrium is

$N_a = \overline{N}_a$, and

(i) $N_e = \overline{N}_e$ if $p > c - \beta\overline{N}_a^2 / (\overline{N}_a + \overline{N}_e)$

(ii) $N_e = \overline{N}_a^2 / (c - p) - \overline{N}_a$ if $c - \beta\overline{N}_a < p < c - \beta\overline{N}_a^2 / (\overline{N}_a + \overline{N}_e)$

(iii) $N_e = 0$ if $p < c - \beta\overline{N}_a$

Proof. When $a < c < a + \beta\overline{N}_a^2 / (\overline{N}_a + \overline{N}_e)$, altruistic donors get positive utility for any N_e if $N_a = \overline{N}_a$. Hence, $N_a = \overline{N}_a$. We consider three cases:

(i) If $p > c - \beta\overline{N}_a^2 / (\overline{N}_a + \overline{N}_e)$ and $N_a = \overline{N}_a$, egoists get positive utility for any N_e. Hence, $N_e = \overline{N}_e$.

(ii) If $c - \beta\overline{N}_a < p < c - \beta\overline{N}_a^2 / (\overline{N}_a + \overline{N}_e)$ and $N_a = \overline{N}_a$, egoists get negative utility if $N_e = \overline{N}_e$ and a positive utility if $N_e = 0$. Hence, the equilibrium condition requires that $u_e = p - \beta\overline{N}_a^2 / (\overline{N}_a + N_e) - c = 0$, or $N_e = \overline{N}_a^2 / (c - p) - \overline{N}_a$.

(iii) If $p < c - \beta\overline{N}_a$, egoists have a negative utility for any N_e. Hence, $N_e = 0$. ///

Note that the outcomes are like in Result 1. All altruists donate, and the equilibrium number of egoistic donors depends on costs and the relative size of the positive and negative externalities, and in addition on the price. What is the medium–run effect of the financial reward in this case? If all egoists already donated before, the payment will have no effect. If some egoists previously donated, a monetary incentive will encourage more to donate, perhaps even all. If no egoists donated previously, a financial reward will encourage (some) to donate, provided that the reward is high enough. Hence, the number of egoistic blood donors will either increase, or stay unchanged. In the first case, the social reward from donating decreases. However, if $c < a + \beta \overline{N}_a^2 / (\overline{N}_a + \overline{N}_e)$, even if all egoists supply blood the negative externality they impose is not strong enough to discourage altruists from donating. Hence, there is no crowding out and all altruists will keep donating.

An example of the dynamics of the system is shown in Figure 2.

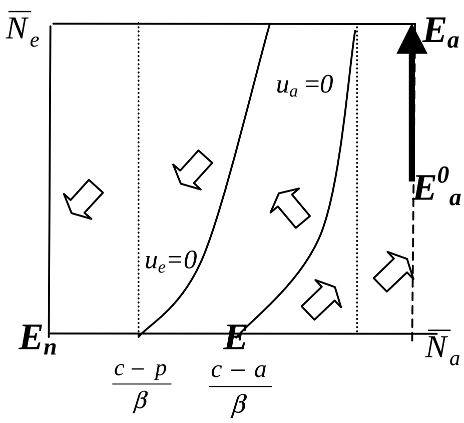

Figure 2: Medium – run dynamics for
$a < c < a + \beta \overline{N}_a^2 / (\overline{N}_a + \overline{N}_e)$

Here, $\boldsymbol{E^0_a}$ denotes the old equilibrium with all altruists donating, and $\boldsymbol{E_a}$, $\boldsymbol{E_s}$ and $\boldsymbol{E_n}$ are the new equilibria. The parameters are chosen such that in $\boldsymbol{E^0_a}$, $0 < N_e < \overline{N}_e$, while $N_e = \overline{N}_e$ in $\boldsymbol{E_a}$. The dotted lines mark the boundaries of the basins of attraction of the equilibria, and the black arrow show the path from $\boldsymbol{E^0_d}$ to $\boldsymbol{E_d}$. It is readily seen from the positions of the two indifference curves that Figure 2 is drawn for the case where $p>a$. Introducing a price $p > c - \beta \overline{N}_a$ will shift the $u_e = 0$ curve upwards, which means that the number of egoistic donors will increase (unless it was already $\overline{N}_e$), although it may stay lower than $\overline{N}_e$. Since after this change the system is still in the basin of attraction of the equilibrium with donors, the number of altruistic donors will remain $\overline{N}_a$. In this case, $\boldsymbol{E_a}$ is the new equilibrium.

Let us now turn to long-run, stochastic dynamics where people sometimes make mistakes. Even though in the case considered here introducing a financial reward does not have adverse effects on blood supply in the medium run, it may very well have adverse effects in the long run, by affecting the stochastic stability of the equilibrium with donors. The condition under which an equilibrium with all altruists donating is stochastically stable is the same as in the case without a financial reward:

$$I\left[\overline{N}_a - \frac{c-a+\sqrt{(c-a)^2+4(c-a)N_e}}{2\beta}\right] > I\left[\frac{c-a}{\beta}\right].$$

If N_e increases enough after the financial reward is introduced, the equilibrium with donors stops being stochastically stable. This can also be observed in the figure: the distance to the boundary of the basin of attraction is shorter from the new than from the old medium-run equilibrium. Hence, it takes fewer agents to make a mistake to move out of the basin of attraction. More importantly, this distance may become even shorter than the distance from the equilibrium without donors to the boundary of its basin of attraction. In this case, even though the blood supply will increase in the medium run, the social norm will be crowded out in the long run and the blood supply will eventually fall to zero.

In the rest of the section we deal with the case in which the financial reward crowds out the social norm already in the medium run, when people are fully rational.

Result 5. Suppose that $a+\beta\overline{N}_a^2/(\overline{N}_a+\overline{N}_e) < c < a+\beta\overline{N}_a$. When a $p>0$ is introduced, the new medium-run equilibrium is

(i) $N_a = \overline{N}_a$ if $p<a$, and

(a) $N_e = \overline{N}_a^2/(c-p) - \overline{N}_a$ if $p > c-\beta\overline{N}_a$ and $p<a$

(b) $N_e = 0$ if $p < c-\beta\overline{N}_a$ and $p<a$

(ii) $N_a = 0$ and $N_e = 0$ if $a<p<c$

(iii) $N_a = 0$ and $N_e = \overline{N}_e$ if $c < a+\beta\overline{N}_a^2/(\overline{N}_a+\overline{N}_e)$ and $p>c$

Proof. *(i)* Suppose $p<a$. We consider both cases in turn.

(a) If $p > c-\beta\overline{N}_a$ and $N_a = \overline{N}_a$, the egoists' utility is negative when $N_e = \overline{N}_e$, since $u_e = p+\beta\overline{N}_a^2/(\overline{N}_a+\overline{N}_e)-c < a+\beta\overline{N}_a^2/(\overline{N}_a+\overline{N}_e)-c<0$ (by assumption), but positive when $N_e = 0$, since $p+\beta\overline{N}_a - c > 0$. Hence, if in the equilibrium

$N_a = \overline{N}_a$, the number of egoists is such that they are indifferent between donating or not. Therefore $N_e = \overline{N}_a^2 /(c - p) - \overline{N}_a$. At this value of N_e, however, altruists will still prefer to donate as $u_a > u_e = 0$, where the inequality follows from $p < a$.

(b) If $p < a$ and $p < c - \beta\overline{N}_a$, egoists' utility is negative even if $N_a = \overline{N}_a$, and hence no egoist will donate blood. As the utility of altruists does not change, $N_a = \overline{N}_a$.

(ii) Suppose to the contrary that $N_a > 0$ This implies that $u_a \geq 0$, but as $p > a$, $u_e^t > u_a^t$ for any N_a^t and N_e^t, which in turn implies that $u_e > 0$ and $N_e = \overline{N}_e$. However, this contradicts the fact that $u_a = a + \overline{N}_a^2 /(\overline{N}_a + \overline{N}_e) - c < 0$. Hence, $N_a = 0$ and $u_e = p - c < 0$ implies $N_e = 0$.

(iii) Suppose that $p > c$. Then, egoists always get positive utility from donating blood. Hence, $N_e = \overline{N}_e$. From $c > a + \beta\overline{N}_a^2 /(\overline{N}_a + \overline{N}_e)$ it follows that when $N_e = \overline{N}_e$ the utility of altruists must be negative. Therefore, $N_a = 0$. ///

In the situation described in Result 5, a large number of egoistic donors may discourage altruists from donating (unlike in the case described in Result 4). Then, the effect of introducing a price will depend on how high it is. If it is low, no or few egoists will be attracted, negative network externalities will be low and altruists will still find it worthwhile to donate. If the price is higher, many egoists will be attracted, social reward will become too low and altruists will stop donating. This is the crowding out effect: when altruists stop donating, the norm disappears and the only motivation for donating blood is the financial reward. If the price is lower than the cost of donating, egoists will stop donating as well and the total blood supply will fall to zero. This is the worst possible situation: the social norm has been crowded out and the financial reward by itself is not large enough to compensate for the cost. If the social norm has been crowded out and the price exceeds the cost, the egoists will donate in the new equilibrium. In comparison with the old equilibrium, the nature of a typical donor has changed, however: before he was likely to be an altruist, now he surely is an egoist. Total blood supply may decrease or increase, depending on the total numbers of altruists and egoists in the population. However, even if the supply increases, the society is not necessarily better off, because when the social norm disappears, the cost of obtaining blood increases substantially.

The medium-run dynamics of the system, and the path form the old to the new equilibrium in three cases of Result 5 are illustrated in figures 3*a*, 3*b* and 3*c*. When $p > a$, there is only one new equilibrium, denoted by ***E.***

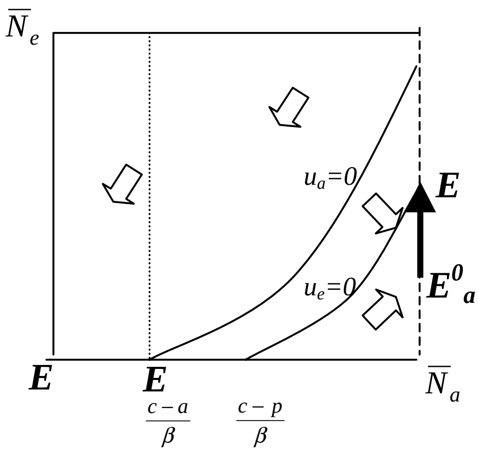

Figure 3*a*: Medium – run dynamics: Case *(i)*, *p<a*

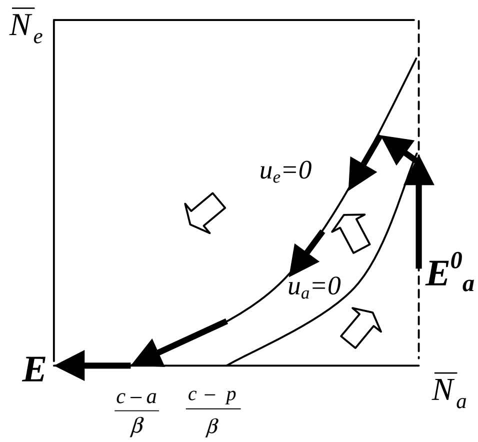

Figure *3b*: Case *(ii)*: *a<p<c*

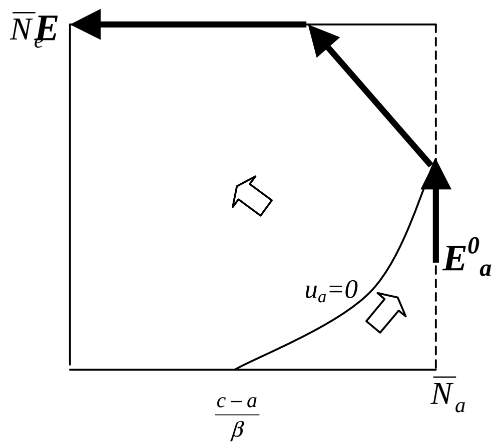

Figure 3*c*: Case *(iii): p>c*

Again, the black arrows show the transition from the old to the new equilibrium. Introducing a financial reward shifts the egoists' indifference curve upwards. If $p < a$ (as in Figure 3*a*), the egoists' indifference curve lies below that of the altruists. Hence, the price does not attract enough egoists to make altruistic donors change their behavior. If $a < p < c$ (as in Figure 3*b)*, the egoists' indifference curve lies above that of altruists, which implies that the price will attract enough egoists to make the altruists stop donating. The number of altruistic donors will start decreasing, but the number of egoistic donors will keep increasing until the system reaches the egoists' indifference curve. From that moment onwards, both N_a^t and N_e^t will gradually fall to zero. Finally, if $p > c > a$ (as in Figure 3*c*), N_e^t is always increasing, while the number of altruistic donors decreases and eventually falls to zero.

How about the long-run dynamics in this case? When $p > a$, there is only one medium-run equilibrium, which must also then be the stochastically stable equilibrium. When $p < a$, there are two medium-run equilibria, which means that in the medium run the social norm is not crowded out. In the long run, however, the same analysis applies as in the case described after Result 4: if N_e increases enough due to the financial reward, the equilibrium with donors may stop being stochastically stable. Thus, in the long run crowding out may occur, even though in the medium run the supply of blood increases.

5. Withdrawing the financial reward

In the previous section we have seen that introducing a monetary incentive may have an adverse effect on blood supply. When the authorities responsible for collecting blood realize that the social norm disappears, they may decide to abandon the payment in order to restore the previous situation. In this section we show that this may fail to improve the situation. Withdrawing the financial reward shifts the egoists' indifference curve back to the old position. The same two medium-run equilibria exist as before the payment was introduced. Thus, when the equilibrium with donors is stochastically stable (see Proposition 1), it will appear in the long run. However, in the medium run, our society may not return to the equilibrium with donors, but instead move towards the equilibrium with without any blood donation. This happens almost surely when at the moment of withdrawing the payment the system is located in the basin of attraction of $\boldsymbol{E_n}$, the equilibrium without donors.

It is easy to see that this will be the case if altruists did not supply blood when $p > 0$. In this case the social reward for donating had been crowded out and when the financial reward is also removed, there is no immediate reason to donate. On the other hand, the society will return to the initial situation with donors if the social norm has not been crowded out and altruists kept donating when $p > 0$. Withdrawing the payment lowers the incentive for egoists to donate, but altruists will keep donating.

Equilibria for p=0 have already been described in Result 3. Result 6 below states which of the equilibria will arise in the medium run after the financial reward has been removed. In the statement of Result 6, N_a^0 denotes the number of altruistic donors at the moment the financial reward is taken away.

Result 6. When the financial reward is removed, the medium run equilibrium will be:

(i) the equilibrium with all altruists donating, if $N_a^0 = \overline{N}_a$.

(ii) the equilibrium with no donors, if $N_a^0 = 0$.

Proof. (i) When the payment is removed, the number of egoistic donors will be unaffected or decrease. Hence, the utility of altruistic donors will not decrease, and therefore $u_a > 0$ and $N_a = \overline{N}_a$. *(ii)* The financial reward does not influence altruists' utility and when it is removed u_a remains negative as $s^t = 0$, and $N_a = 0$. ///

Result 6 can easily be illustrated by looking at Figures 1*a*, 1*b* and 1*c*. Part *(ii)* is obvious: any initial state in which $N_a^0 = 0$ lies in the basin of attraction of the equilibrium without donors. Similarly, part *(i)* is obvious if $c < a + \beta\overline{N}_a^2 /(\overline{N}_a + \overline{N}_e)$, because then any initial state in which $N_a^0 = \overline{N}_a$ lies in the basin of attraction of the equilibrium with donors. If $c > a + \beta\overline{N}_a^2 /(\overline{N}_a + \overline{N}_e)$, $N_a^0 = \overline{N}_a$ means that the social norm has not been crowded out by the financial reward, which only could have happened if $p < a$. The last inequality implies that the initial equilibrium (which arose when $p > 0$) lies below the altruists' indifference curve, and therefore in the basin of attraction of the equilibrium with donors.

6. Discussion and conclusions

With the help of a simple model, we have given an interpretation to the story of Titmuss: a social norm to donate blood may disappear after a financial reward is introduced, and once the norm has been destroyed, it can take a very long time before it re-emerges. We have also shown how the norm could have arisen in the first place, namely as the result of a long history with a voluntary donation system. Our results point to potential dangers hidden in the use of financial incentives in situations in which social norms play an important role. Even if the social norm is not crowded out immediately, it may become more fragile due to the use of financial rewards and, therefore, disappear in the long run. Moreover, even if blood supply increases in the long run due to the paid system, the society is not necessarily better off, since it has to pay now for a resource that was previously obtained at a low cost.

Does it mean that existing financial rewards should be removed? In the short and medium run, it is often likely to make the situation even worse. More specifically, if a social norm has already been crowded out, removing the payment leads to the breakdown of the blood supply in the medium run. Hence, if waiting for the norm to reappear is not a feasible option, it makes more sense to keep the reward in place. If the social norm has not (yet) disappeared, the situation is more ambiguous: on the one hand, removing the payments may decrease blood supply, but on the other hand, it may prevent the norm from disappearing in the long run.

Let us make a few comments about the medium–run mechanics of the model. For the medium-run (deterministic) crowding out to take place it is crucial that two equilibria can emerge, and that introducing a financial reward pushes the system from the equilibrium in which all altruists donate to the equilibrium without donors. These conditions are realized by the existence of two groups of individuals, of which one is the source of positive, and the other negative externalities.

The positive network externalities created by altruistic donors for other altruists ensure the existence of two equilibria; in addition, the restriction $a < c < a + \beta\overline{N}_a$ is needed to make sure that the critical number of altruists necessary to induce other altruists to donate lies between zero and their total number (in other words, an altruist's utility from donating is negative if no other altruists donate, but positive if all other altruists donate). The condition can also be satisfied if $a = 0$, hence, it is not necessary that altruists are really "altruistic".

The second condition for crowding out, which states that introducing a financial reward causes a shift from one equilibrium to the other, is ensured by properties of the model. First, as a monetary reward is introduced, the number of egoistic blood suppliers increases, while the number of altruistic blood suppliers remains constant. This is a consequence of p being included in the utility function of egoists, but not altruists. Second, egoists create negative externalities for altruists. The parameter restrictions make sure that the number of egoists is not yet maximal before financial reward is introduced $(c > \beta \overline{N}_a^2 / (\overline{N}_a + \overline{N}_e))$, and that the negative externalities can be strong enough to discourage an altruist from donating even though all other altruists still donate $(c > a + \beta \overline{N}_a^2 / (\overline{N}_a + \overline{N}_e))$.

The fact that egoists also care about the social reward is not crucial for the crowding out: it makes the results richer by allowing egoists who donate purely to gain social reward and reduces the differences between agents, but the "crowding out" effect relies only on discouraging the altruists from donating. The assumption that altruists do not care about money justifies the social reward from being seen as an altruist. However, the crowding out effect can also take place if the financial reward is included in their utility function, provided that they care about it significantly less than egoists (to make sure that the number of egoistic suppliers increases faster than that of the altruistic suppliers as a financial reward is introduced), and that the financial reward is not too high (if it were sufficiently high, the utility of donating for altruists would be positive even in the presence of strong negative network externalities).

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