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Solving the kidney shortage via the creation of kidney donation co-operatives☆

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ABSTRACT

Many people object to the creation of a market for kidneys on the grounds that such reform would hurt those patients unable to afford the market price of a kidney and that donors do not understand the risks they are taking when donating. In this paper, we propose a mechanism, the kidney co-operative, designed to provide sufficient incentives to alleviate the kidney shortage while at the same time addressing the concerns regarding the potential losers from reform. We show that it is reasonable to expect that the number of transplants will be larger under the kidney co-operative mechanism than under either the status quo or a conventional market mechanism.

1. Introduction

The kidney shortage is a serious problem. In the United States, 99,061 people were on the waiting list for new kidneys as of December 22nd 2016, while only about 17,000 kidney transplant operations take place every year.[1] Moreover, nearly 3000 new patients are added, on average, to the waiting list each month. The consequences of the shortage are dire: 4761 patients died in 2014 in the United States alone while waiting for a kidney transplant.[2]

At the core of this problem lies a basic, inescapable fact: one cannot compel potential donors to donate. The traditional solution to a problem of this sort is to allow a conventional market for live donor kidneys to develop, a solution advocated, for example, by Becker and Elias (2007). This solution has, however, been rejected for a variety of reasons by a large fraction of the population in the US and elsewhere.[3] For this reason, Roth et al. (2004, 2005a,b, 2007) began the important task of studying and promoting the institution of kidney paired donations as a solution to the kidney shortage. Unfortunately, the shortage is orders of magnitude larger than the number of kidney paired donations that are successfully achieved on an annual basis. It is therefore important to develop alternatives that would offer a large-scale solution to the kidney shortage.

As this paper demonstrates, the creation of a conventional market is not the only way to harness the power of incentives to motivate a large number of potential donors to donate. The solution we investigate, which we call a *kidney co-operative*, is designed to address the two main reasons why people consider the creation of a conventional market for live donor kidneys unacceptable: first, that such a market would completely exclude those patients unable to afford the kidney; and second, that donors will not understand the risks they are taking when donating, and that they will therefore not be properly compensated for taking that risk. Moreover, we show that it is reasonable to expect that the number of transplants will be larger under the kidney co-operative mechanism than under a conventional market mechanism.

Kidney co-operatives follow a simple set of principles. Patients in need of a kidney donate a set amount of money to the co-operative if they are able to do so, whereas those who need a kidney but are unable to make the requisite monetary donation go on a

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[1] Organ Procurement Transportation Network (2016).
[2] National Kidney Foundation (2016).
[3] For a broad discussion on people's perceptions regarding payment for organs see Leider and Roth (2010).

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"waiting list". Healthy patients donate kidneys to the co-operative, which first allocates kidneys to patients who donated money, then disburses any remaining organs to those on the waitlist. All revenue raised by the co-operative is split equally among the kidney donors, who also receive lifetime "kidney insurance".

Kidney co-operatives are not conventional markets, as some key conditions that define well functioning markets are not met. First, a kidney co-operative does not aim to maximize profits (either for itself or for its members). Second, the "law of one price" does not hold, as patients donate an amount per kidney that is larger than the cash payment that a donor receives for his or her donation. Third, the market "does not clear", that is, the quantity of kidneys supplied by the donors weakly exceeds the quantity demanded by paying patients. A kidney co-operative is, instead, a self-financing mechanism that, when designed efficiently, can maximize the number of kidney transplants that take place in the population at a minimum risk to the donors, while keeping all transactions voluntary. Furthermore, kidney co-operatives are (weakly) Pareto improving relative to the status quo.

2. Background

The simplest environment in which to consider a kidney co-operative is one in which the distributions of reservation prices for kidneys among both donors and patients is continuous and is known to the co-operative managers, when there is no risk to the donors from donating, and when patient/donor blood type incompatibilities are ignored. We relax these assumptions in Section 4. Throughout the analysis, we treat all kidneys as being of equal medical quality, and all patients as being equally in medical need of a kidney. Though these assumptions can also be relaxed, we maintain them throughout.

The size of the population of patients is denoted by $D > 0$. Patients who contribute a set amount of money, p, designated by the co-operative, are called *contributing patients*. Patients who do not contribute are called *non-contributing patients*. The total amount of money collected by the co-operative divided by the number of kidneys donated is called the *co-operative dividend*, δ.

Each kidney donor forms an expectation of the co-operative dividend. Let the expectation for donor j be equal to δ_j, a real number. We postulate that, for each potential donor j there is a threshold $c_j \geq 0$ such that the potential donor donates if $\delta_j \geq c_j$ and does not donate otherwise. The distribution of reservation prices, c_j, for the potential donors is given by μ. Thus, if all potential donors expect a dividend equal to δ, the number of kidneys donated is given by $F^S(\delta) = \int 1_{\{c \leq \delta\}} d\mu(c)$, depicted in Fig. 1. Let $\bar{c}$ be the smallest dividend level δ such that $F^S(\delta) = D$. Anecdotal evidence suggests that $\bar{c}$ is well above zero.[4]

Kidneys are essential to life and all patients in need of one value them greatly. We thus assume that, in the absence of wealth constraints, every patient i is willing to contribute $v_i \geq \bar{c}$ to the co-operative to secure a kidney (for simplicity, we assume v_i is equal to $\bar{v}$ for all i). The alternative for each patient is to go on the waiting list and hope to be assigned a kidney this way, which, for patient i, happens with probability θ_i. Thus, without wealth constraints, we postulate that patient i makes a contribution of size p to the co-operative when $\bar{v} - p \geq \bar{v}\theta_i$, that is, when $p \leq \bar{v}(1 - \theta_i)$, and does not contribute otherwise.

[4] Note that c_j need not be finite for all potential donors, i.e. some donors may not be willing to donate at any price. The following analysis only requires that there exists some price $\bar{c}$ for which at least D donors would be willing to donate. This does not seem like a restrictive assumption as, for example, in the United States, there are over 2000 adults for every patient in need of a kidney.

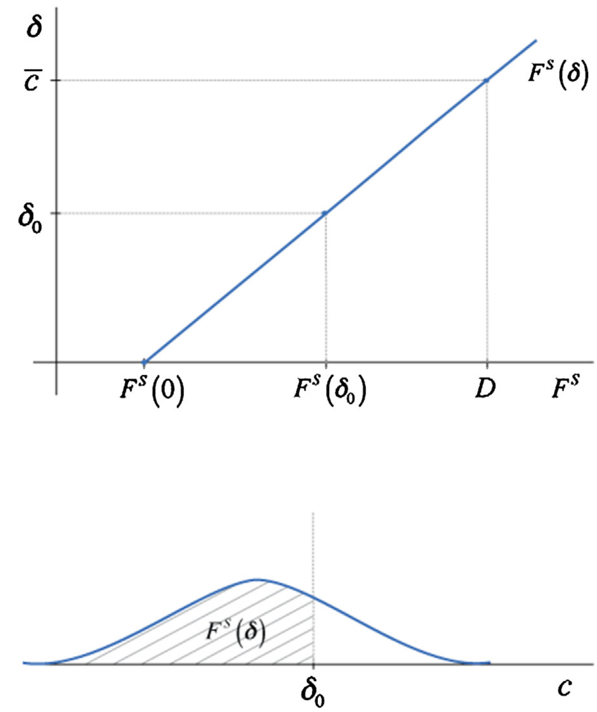

Fig. 1. The donors.

In practice, wealth constraints do matter, as not all patients may be able to contribute an amount equal to p, even if they would like to. Therefore, in the presence of wealth constraints, patient i with wealth level w_i makes a contribution of size p to the co-operative when $p \leq \min\{\bar{v}(1 - \theta_i), w_i\}$, and does not contribute otherwise.

The wealth distribution for the patients is given by ρ. Thus, if all patients believe that the probability of obtaining a kidney by going on the waiting list is equal to θ, the number of contributing patients is given by $F^D(p, \theta) = \int 1_{\{p \leq \min\{\bar{v}(1-\theta), w\}\}} d\rho(w)$, depicted in Fig. 2. Note that $F^D(0, \theta) = D$ for any $\theta \in [0, 1)$. We denote $F^D(p, 0)$ simply as $F^D(p)$.

The current situation in the United States can be described using the above notation. Under the status quo, $p^0 = \delta^0 = 0$ and $D - F^S(0) > 0$, thus, there is a kidney shortage. All patients go on the waiting list and have a positive probability of obtaining a kidney that is equal to $\theta^0 = \frac{F^S(0)}{D}$. Anecdotal evidence suggests that $F^S(0)$ is well below D and therefore that θ^0 is small.

Under the conventional market mechanism, all patients buy kidneys from donors at a single price and markets clear, that is, $p^m = \delta^m > 0$ and $F^D(p^m, \theta^m) = F^S(p^m) = F^m$, implying that $\theta^m = 0$. There is a smaller kidney shortage, $D - F^S(p^m)$. Thus, under the market mechanism, there are more transplants than under the status quo. However, the outcome under this mechanism is not a Pareto improvement over the status quo, as a fraction of the patients (those with an inability to pay prices above p^m) go from having a positive probability of obtaining a kidney under the status quo to a zero probability of obtaining a kidney under the conventional market mechanism. Fig. 3 contrasts the status quo with the conventional market mechanism.

In what follows, we sometimes assume that the equilibrium of the market mechanism occurs on the "inelastic portion of the demand curve for kidneys, F^D"; we call this Assumption 1. Algebraically, this assumption states that:

$$\left| \frac{\partial F^D(p^m, \theta^m)}{\partial p} \frac{p^m}{F^m} \right| < 1.$$