Price Theory I: Problem Set 3 Question 2

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Problem Set 3 Question 2

“Many organs, especially kidneys, are transplanted each year- this question concentrates on kidney transplants. Because hospitals and patients are not allowed to buy organs or make any transfer to donors, all donors must offer their organs for free. As a result, an individual needing a kidney must typically wait several years before he gets one.

A typical alternative to receiving a kidney transplant is to undergo ongoing kidney-dialysis treatments, which are administered by hospitals. For this reason, we refer to potential kidney recipients as ‘dialysis patients’ or just ‘patients.’”

Background

- In the U.S., dialysis and transplantation are largely paid for by Medicare, so there are limited direct financial costs to patients.
  - However, there are large indirect costs to e.g. dialysis (takes a lot of time every week).
- Kidney transplantation is generally a more effective and cost efficient treatment for patients, if they are healthy enough.
- Kidney donations may come from deceased donors, relatives/friends of the patient, purely altruistic donors, or relatives/friends of **other** patients (paired donation).

Background

- End Stage Renal Disease (ESRD, aka "Kidney Failure"):
  - Incident ESRD: 132k/year
  - Total with ESRD: 784k
- Dialysis:
  - Starting Dialysis: >112k/year
  - Total on Dialysis: 554k
  - **Cost:** **$79k/year**
  - **Five Year Survival Rate:** ~**40%**
  - **Typical Schedule:** **3 sessions/week of 3-5 hours each**

Background

- Transplantation:
  - **Transplants:** **22k/year**
  - Total with Transplants: 230k
  - **Cost:** **$37k/year**
  - **Five-Year Survival Rate:** ~**80%**
  - **Added to Waitlist:** **27k/year**
  - On Waitlist: 80k
  - Dialysis Patients on Waitlist: 13.5%
  - **Median Transplant Wait Time:** **4 years**
- Source: USRDS 2020 Annual Report (data as of 2018)

Background

- Transplantation is way cheaper than dialysis and also has way better survival rates!
  - This is even ignoring patients' indirect costs of dialysis.
  - However, the populations are not fully comparable (sicker patients are less likely to be eligible for a transplant, so will be on dialysis instead).
  - Still, transplantation is consistently preferred to dialysis when both are possible.
- More patients are added to the waitlist than get transplants every year.
  - As a result, the average wait time is 4 years.
  - A significant fraction of patients on the waiting list die or get too sick before they can get a transplant.

Part (a) - Model

"Sketch a model that determines the equilibrium number of kidney donations per unit time and waiting time for patients. Would an increase in the number of willing donors increase transplants one-for-one?"

Part (a) - Model

- N eligible patients "arrive" every year and are placed on the kidney waiting list. They undergo dialysis until they receive a transplant or exit eligibility (through death or worsened condition), which occurs at constant rate d per year.

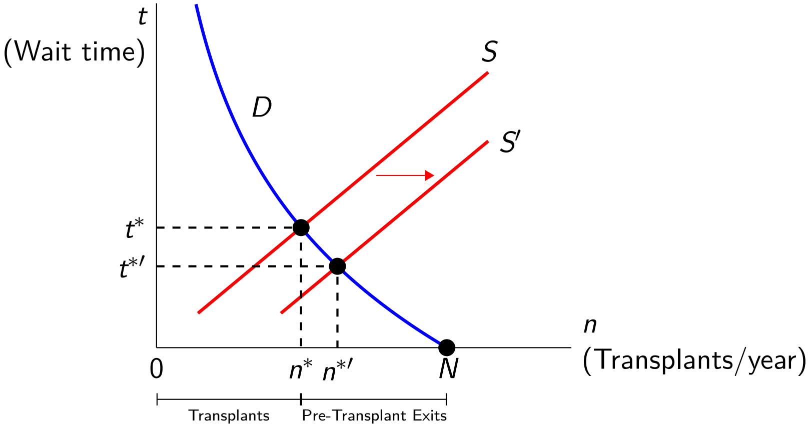
- Kidney donors are "altruistic," meaning they care about patients' wait time, but kidney supply is upward sloping in wait time since altruists only donate if the wait time cost to a patient is more than the donors personal cost of donation (e.g. surgery cost, missing work).

- For simplicity, assume all patients are the same (same exit rate), ignore discounting, and patients entering are guaranteed a transplant in clearing time t^* years if still eligible. Donors differ (creating upward sloping supply), but we will not examine this in detail.

Part (a) - Model

- Finally, assume the “market” is in steady state.
  - Annual supply and demand curves have been the same for a long time so the clearing point is the same each year and there are no transitory factors affecting it.
    - E.g. an unexpectedly large number of patients in the previous year lengthening the waitlist/wait time.
- This gives us a relatively standard supply and demand framework, but wait time, not price, clears the “market” and the reasons for supply/demand response to wait time are different from usual.

Part (a) - Model



- **Answer:** An increase in donors would not increase transplants one-for-one.
  - Intuitively, the increase in donors reduces wait time in equilibrium, so fewer potential donors actual donate than the increase (elastic supply).

Part (b) - Patient Welfare

"Would patients be better off with a cash market for kidney donations?"

Part (b) - Patient Welfare

- To extend our model, I'll assume that the government continues to pay for dialysis/transplantation and the kidney waitlist (supplied by altruistic donors) still exists, but additionally patients can buy a kidney and get a transplant right away.
  - Other possible extensions: government pays for kidneys directly (Iran's case), waitlist no longer exists (everyone buys a kidney), ...

- Assume that patients have a yearly cost of treatment (dialysis) c_t and a cost of death (exit) c_d.
  - For a given wait time, patients would pay up to some amount based on those costs for a kidney (and transplant) immediately instead.
  - Cost of waiting increases in wait time. Appendix

- Altruistic donors can continue to donate to the waitlist, but they can instead sell their kidneys if they choose.
  - Additionally, there are non-altruistic donors/sellers who would not have donated before the cash market.

Part (b) - Patient Welfare

- Unless one of the markets is inactive, the cost of waiting on the waitlist will equal the cash market kidney price.
  - Otherwise all patients would go to the "cheaper" market.
- In equilibrium and steady state, patients who have waited some time already will not buy a kidney (since price $>$ waiting cost).
  - When patients enter, they are indifferent between buying a kidney and waiting.
  - Patients who buy exit the market, they no longer need a kidney.
  - Patients who wait could buy a kidney in the future, but they don't want to since their wait time is lower but the price is the same.
    - If kidneys became cheaper, patients who hadn't waited too long already would buy instead.
- This allows us to consider a single figure, where the y-axis is time or price (appropriately monotonically transformed).
- Assume we're in this case for the rest of the question.

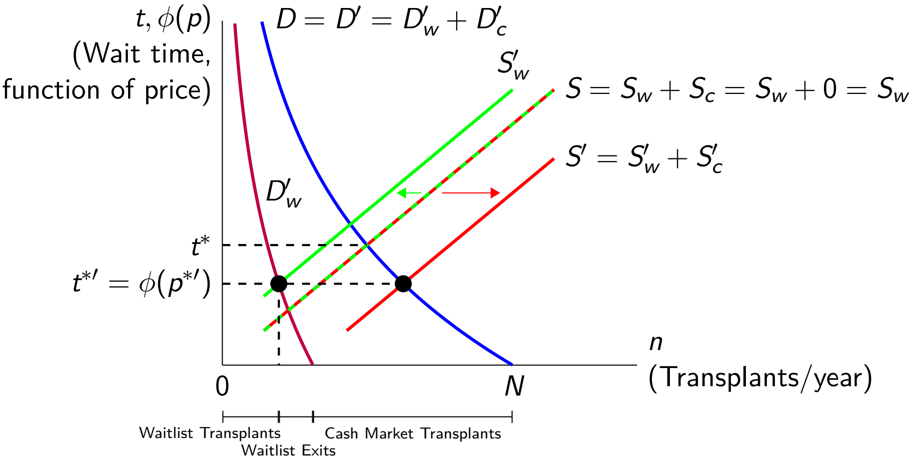
Part (b) - Patient Welfare

- Total supply increases. Altruistic donors respond the same to a given waiting time, but may additionally respond because of the cash price. Non-altruistic sellers are wholly new to the market. Demand is unaffected by assumption (no moral hazard issues, for example).

- Patients pay a lower "price" (in cash or waiting time). Some share waits (some will exit before they receive a kidney) and the remainder buys up front.
  - This result may change with heterogeneous patients, for example if some are unable to buy a kidney.

- The quantity intersection is no longer interpretable as transplants per year, it's transplants per year if everyone waited the waiting time (including cash buyers).
  - The actual number of transplants per year is higher, though patients do not capture all of this benefit since some are paying.
  - For the same reason the total supply curve is sort of a future "discounted" supply curve.

Part (b) - Patient Welfare



- **Answer:** Patients are better off with a cash market for kidneys, they get more ("discounted") transplants for a lower "price". Appendix

Part (c) - Donor Welfare

"Would donors be better off with a cash market for kidney donations?"

Part (c) - Donor Welfare

- Clearly non-altruistic donors are better off, they didn't participate before, but now if they participate they get paid enough that is it worthwhile for them.
- Analyzing altruistic donors is trickier, if waiting time is treated as a price for them you get the somewhat perverse intuition that these "altruistic" donors prefer higher waiting times.
  - Instead, as before assume that altruistic donors benefit from lower wait times but only donate if the waiting time cost (or waiting time cost plus kidney price for the cash market) is more than their personal donation cost.

Part (c) - Donor Welfare

- Consider altruistic and non-altruistic donors in several cases, whether or not they were donating to the waitlist before the cash market introduction and which market they donated/sold to (or neither) after the introduction).

	Pre-		Post-	
Donate to ...	Waitlist	$\rightarrow$	Waitlist:	Better off (lower wait time).
	Waitlist	$\rightarrow$	Cash:	Better off (lower wait time + compensation).
	Waitlist	$\rightarrow$	None:	Better off (lower wait time).
	None	$\rightarrow$	Waitlist:	Doesn't occur (lower wait time).
	None	$\rightarrow$	Cash:	Better off (lower wait time and/or compensation).
	None	$\rightarrow$	None:	No worse off (lower wait time/no compensation).

Part (c) - Donor Welfare

- **Answer:** Donors are better off in aggregate and no worse off individually.

Part (d) - Physician Opposition

"The idea of having a cash market is regularly debated in public policy, with hospitals and physicians strongly objecting. What are some of the factors that cause them to oppose a cash market while patients and donors favor one?"

Part (d) - Physician Opposition

- **(Answer)** Possible reasons:
  - Financial - Dialysis is more costly then transplantation, that's revenue to hospitals and physicians. If it's also more profitable (which seems likely), hospitals and physicians may find it in their best financial interest to restrict supply of transplants, including opposing a cash market.
  - Philosophical - Does the idea of "do no harm" apply to transplants? Transplants "harm" the donor for no personal benefit, unless the donor knows the recipient or donates out of a sense of altruism. Can transplantation be justified if the donor only does so for payment?
  - "Repugnance" - Many people have a deep-rooted negative reaction to the idea of "organ markets." Perhaps patients and donors overcome this instinct because they have a personal stake in the matter and recognize the personal benefits of such markets. Hospitals and doctors generally lack those encouragements.

Part (e) - Expense Compensation Policy

"The U.S. continues to prohibit organ purchases, although recently President Trump did allow hospitals and/or patients to pay cash compensation to donors for the donor's medical expenses. Use your framework from (a) to analyze the effects of this new rule."

Part (e) - Expense Compensation Policy

- **Answer:** This policy simply shifts the supply curve of kidney donations outwards. Transplants per year increases, average waiting time decreases.
  - The policy reduces the cost of donation at any waiting time, so supply increases.
  - See the graph for (a), it's the same idea.

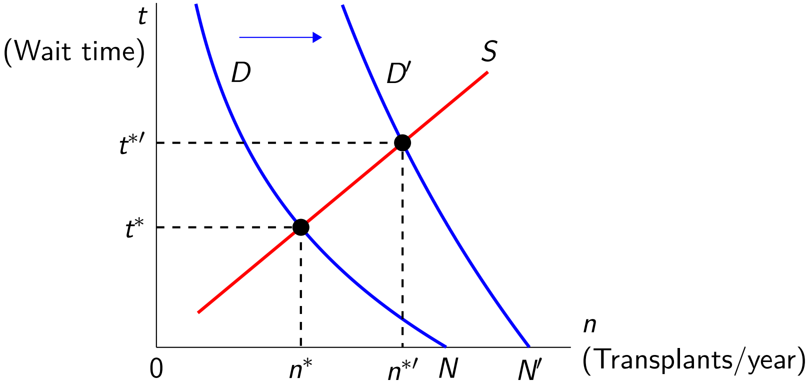
Part (f) - Iranian Kidney Market

"During the Iran-Iraq war (circa 1980), many Iranian soldiers were poisoned, with one of the symptoms being kidneys that do not function. Does your framework help explain why Iran became the only country in the world to allow cash payments for kidney donations?"

Part (f) - Iranian Kidney Market

- This event shifts the demand curve for transplants outwards due to many more people with kidney failure.
  - It may also increase the slope of the demand curve through a decreased death rate.
    - Soldiers are young so may be less likely to “exit” compared to the otherwise generally elderly patient population.
- Both of these changes increase equilibrium waiting time and transplants per year.
- (I ignore possible shifts in supply, for example removing poisoned soldiers from the potential donor population.)

Part (f) - Iranian Kidney Market



- **Answer:** The costs of not having a kidney market (to patients, potential donors, the government, and society) increase with waiting time and patient population, so these changes may have encouraged the government to allow payments for kidneys.

Part (g) - Kidney Price Forecast

"Before Iran's market opened, how would you go about projecting the equilibrium price for donated kidneys? For a U.S. market?"

Part (g) - Kidney Price Forecast

- Projecting the equilibrium price requires estimating:
  - Number of new patients per year: N
  - Exit rate per year: d
  - Patient cost of waiting a year: $(1-d)c_t + dc_d$
  - Kidney supply curve in terms of price (or wait time): $S(P)$
  - Clearing wait time (possibly helpful): t^*

Part (g) - Kidney Price Forecast

- N, and d are physical numbers, easy to observe in the data.
  - These determine the demand curve.
- $((1-d)c_t + dc_d)$ would be estimated.
  - Along with the exit rate, this determines the relationship between wait time and cost (equivalent price).
  - The government could run a pilot program allowing people to pay for a shorter waiting time (sure to be controversial).
  - Researchers could run a survey asking patients how much they would pay to reduce their wait time.
  - Some element of institutional structure could be used to estimate willingness to pay (e.g. different waitlists with different wait times and the implicit costs of getting on those waitlists vary).

Part (g) - Kidney Price Forecast

- $S(P)$ would be by far the most difficult to estimate.
  - $S(P)$ could be completely different from the previous purely altruistic "supply curve" due to the lack of non-altruistic donors and how altruistic donors might respond to cash prices.
  - Similar to patient cost, the government could run a pilot program allowing some people to sell their kidneys for varying prices, or researchers could survey potential donors about willingness to sell.
- Alternately, you could use the exit rate d, estimated patient cost ($(1-d)c_t + dc_d$), and observed wait time t^* to calculate an upper bound on the cash market price.
  - The cash market increases supply without affecting demand, so the equivalent price to the current wait time will be higher than the cash market equilibrium price.

Part (g) - Kidney Price Forecast

- **Answer:** You could project the equilibrium price by estimating several objects, some more difficult than others.
  - You could also avoid estimating the supply curve and get an upper bound.

(Appendix) Recent Articles

- GMO Pig Kidney Transplant
- Economics and Kidney Exchanges

(Appendix) Waiting Cost

- In discrete time for simplicity:

$$
\begin{aligned}
C(1) &= (1-d)c_t + dc_d \\
C(2) &= (1-d)c_t + dc_d + (1-d)C(1) = (1-d)c_t + dc_d + (1-d)((1-d)c_t + dc_d) \\
C(3) &= (1-d)c_t + dc_d + (1-d)C(2) = (1-d)c_t + dc_d + (1-d)((1-d)c_t + dc_d \\
&\quad + (1-d)((1-d)c_t + dc_d)) \\
&= (1-d)c_t + dc_d + (1-d)((1-d)c_t + dc_d) + (1-d)^2((1-d)c_t + dc_d) \\
&\dots \\
C(T) &= \left(\sum_{t=1}^{T}(1-d)^{t-1}\right)((1-d)c_t + dc_d)
\end{aligned}
$$

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(Appendix) Welfare Figure Definitions

- D = Total Demand
  - D_w = Waitlist Demand
  - D_c = Cash Market Demand
- S = Total Supply
  - S_w = Waitlist Supply
  - S_c = Cash Market Supply
- $\phi(\cdot)$ = Monotonic Function relating Price and Wait Time

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