The Effect of Cadaveric Kidney Donations on Living Kidney Donations: An Instrumental Variables Approach

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Abstract:

The lack of pricing data coupled by the presence of altruism creates challenges to estimating substitution patterns in the organs market. This paper proposes using variation in traffic safety laws an instrumental variable for the supply of cadaveric donors. These instruments are then used to identify substitution patterns between living and cadaveric kidney donors. Using panel data from 1988-2008, we find that a 1% decrease in the supply of cadaveric donors per 100,000 individuals increases the supply of living donors per 100,000 individuals between 0.36% to 0.54%. On average, a decrease of four to five cadaveric donations causes an increase of one living kidney donation. Disaggregate living donors into biological donors and non-biological donors, we find the strongest effect is among non-biological donors known to the organ recipient. A 1% increase in the supply of cadaveric donors decrease the supply of kidney donations from this group by 1.54%. Lastly, the supply of cadaveric donations is found to have little or no effect on donations made by biological and anonymous donors.

Keyword: organ donations, altruism, instrumental variables, traffic safety laws

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1. Introduction

On April 21st 2008, there were 101,687 patients awaiting an organ transplant, but only 27,958 transplants were performed in that year.[1] The critical shortage of organs is the result of an artificial price ceiling instituted by the National Organ Transplant Act (NOTA) of 1984, which legislates financial compensation for organs to be unlawful. For this reason, the current supply of organs is generated by *altruistic* cadaveric and living donors.

These donors willfully supply organs without the expectation of compensation, but the decision to donate is not the same for both donor types. Unlike cadaveric donors where the functional value of the organ to the donor is small, living donors must consider the potential long term healthcare cost associated with donating an organ. These costs include an increase in mortality risk, morbidity risk, loss in quality of life, and lost wages generated by time away from work during recovery. Potential living donors must weigh these costs versus alternative sources of organs (cadaveric organs and other living donors) and consider their own future demand for organs when deciding to donate.

Even so, the number of living donors has increased dramatically from 1,769 in 1988 to 5,955 in 2008 or an increase of 237% (see Figure 1). Over the same period, the percentage of biological donors has decreased from 93% to 60% of all living donors. Several factors can account for these changes: introduction of tax incentives for organ donation[2], compatibility

[1] Based on OPTN data as of March 13, 2009. See http://www.optn.org/ (last accessed June 2009).
[2] Currently 13 states have legislation awarding a $10,000 state income tax credit to living donors. Another six states allow living donors to receive paid leave of absence from work for up to 30 days. See http://www.transplantliving.org/livingdonation/financialaspects/statetax.aspx for more information.

websites[3], relaxing donor match requirements (Mandelbrot, 2007), or simply the responsiveness of potential living donors to the shortage of cadaveric donations.

The topic of organ donation has received considerable attention in both the academic literature and the press (Becker and Ellias 2007; Epstein 2008; Howard 2007, Forthcoming; Roth 2007), but there is still limited empirical evidence identifying potential causes for the increase in living donor rates; the trade-offs between living and cadaveric donors; and the change in living donor composition from primarily biological donors to an increase in non-biological donors. Two previous studies do address the substitutability between living and cadaveric donors. Howard (forthcoming) utilized geographic variation in waiting times for organ transplants to estimate the substitutability of living and cadaveric donations. The author finds that a decrease of five kidneys from cadaveric donations is correlated with one additional living kidney donation. Sweeney (2010) exploits a discontinuity in PRA[4] blood levels within a regression discontinuity framework and finds a 10% increase in the likelihood of receiving a cadaveric kidney donation decreases the likelihood of receiving a living kidney donation by 2-3%. We find similar results as these previous studies, but utilize a completely different identification method. In this paper, we propose using variation in traffic safety laws between states as an instrumental variable to identify the substitution patterns between living and cadaveric kidney donations.

With respect to motor vehicle safety laws, we study how changes in seat belt, helmet, and speed limit laws indirectly affect the number of living donors by shifting the supply of cadaveric organ donations. Previous studies have considered how changes in these safety laws

[3] For an example see http://www.matchingdonors.com/

[4] Panel reactive antibody (PRA) is a blood test determining the likelihood of kidney rejection. Individuals with low PRA levels are given less priority on the publicly available supply of organs.

would affect motor vehicle fatalities (Dee 2009) and cadaveric donations (Dickert-Conlin, Elder, and Moore 2009). According to the Organ Procurement and Transplantation Network (OPTN), roughly 16% of cadaveric donations are the result of a motor vehicle accident. Therefore, policy changes intended to affect the number of motor vehicle fatalities indirectly affects cadaveric organ donations. Ashenfelter and Greenstone (2002) estimate that increasing the speed limit from 55 mph to 65 mph on rural highways increased fatality rates by 35%. Dee (2009) finds a 27% reduction in fatalities among motorcyclists when states require helmet use. Dickert-Conlin, Elder, and Moore (2009) build on this result by linking helmet laws to organ donations. The authors find that a national repeal of helmet laws would lead to a one percent increase in the supply of cadaveric organ donations. These studies provide support for a possible link between motor vehicle safety laws and cadaveric donations, but do not consider how these changes in cadaveric donations may affect the supply of living donations.

The supply of living donations may also be influenced by changes in demand. We consider both state level obesity rates and prevalence rates for end stage renal diseases (ESRD) as potential demand shifters. The use of obesity rates to estimate shifts in the demand for organs is motivated by recent medical research connecting obesity and renal disease. The primary risk factor for type II diabetes, a leading cause of renal failure, is obesity. Hsu et. al (2006) finds that obese patients are 6 to 7 times more likely to develop renal failure than individuals of normal weight. In Sweden, Ejerblad et. al (2006) estimates that being overweight at age 20 tripled the odds of chronic kidney failure. These studies highlight the potential link between obesity/ESRD and the demand for kidney transplants.

A secondary link between obesity and the supply of living donors is generated by the allocation system used to determine who receives organs from cadaveric donors. Individuals who are morbidly obese are not considered “good candidates” for organ transplants. These patients receive less priority to access the supply of cadaveric donors. In these cases, living donors can circumvent the allocation system and donate directly to these individuals.

A potential third relationship of obesity with the supply of kidney donations is via the supply of cadaveric donors. Sleck, Deb, and Grossman (2008) find that higher BMI is also associated with a modest increase in organ yield among cadaveric donors, but this relationship is quadratic in nature. Consequently, large values of BMI or obesity can lead to fewer cadaveric donations as there would be fewer viable organ transplant candidates.

The substitution effect between living and cadaveric kidney donations is estimated using two-stage-least squares (2SLS) where variations in motor vehicle safety laws serve as instruments for the supply of cadaveric kidney donations.[5] In order for these variables to be valid instruments, they must be independent of unobserved factors affecting both cadaveric and living donations. For example, the passage of traffic safety laws must be independent of both unobserved levels of altruism in a state and the objectives of organ transplant physicians within a state.

Our primary findings are (1) living donors do respond to changes in the supply of cadaveric donors. On average, living donations decrease by one kidney for a corresponding increase in cadaveric kidney donations of 4 to 5 units; (2) biological donors are non-responsive to changes in the supply of cadaveric donors, but non-biological donors are; (3) within the category of non-biological donors, anonymous donors are less responsive to changes in cadaveric donations than donors who are known to the organ recipient.

[5] A secondary set of instruments used is demographic information for non-medical injury deaths gathered from the Compressed Mortality Files. The sub-sample of injury deaths are associated with deaths where the internal organs are not damaged due to medication and thus are good candidates for donation.

In the following section, we provide a brief overview concerning changes in motor vehicle safety laws in the US. Section 3 describes the data gathered from the Organ Procurement and Transplantation Network as well as changes in state demographics used to conduct the analysis. Section 4 presents the empirical model and results. Lastly, Section 5 concludes and suggests paths for future research.

2. A Brief History of Motor Vehicle Safety Laws

Speed Limits

Prior to 1974, speed limits were determined by states and local governments. The Emergency Highway Energy Conservation Act (EHECA) of 1974 set speed limits to a maximum of 55 mph, which was lower than any existing speed limit within the 50 states. In 1987, Congress modified the EHECA by allowing states to set speed limits not to exceed 65 mph on rural highways. Of the 50 states, 41 states did increase speed limits on rural highways to 65 mph.[6] Politicians were motivated to set the nationwide speed limits to mitigate the fuel energy crisis during the 1970's and 1980's.

In 1995, Congress eliminated the national speed limit restriction. States are now free to choose the maximum speed on both rural and urban highways. By 1997, most states had adopted speed limits of 70 mph or greater on rural highways, but only half set limits above the previous national speed limit of 55 mph on urban highways. As of June 2009, 33 states have speeding limits in excess of 65 mph on rural highways with the highest speed limit of 80 mph in Texas and Utah. Only 14 states have maintained the national speed limit of 55 mph on urban

[6] Only seven states maintained the national speed limit on rural highways: Connecticut, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, and Rhode Island. Delaware, the District of Columbia, and Hawaii did not have highways classified as rural.

highways and the lowest speed limit of 50 mph is found in Hawaii. Figure 2 provides a summary of current speed limits on rural interstate highways by state.

According to the National Highway Traffic and Safety Administration, speeding is associated with roughly one-third of all fatal crashes. In 2007, 13,040 people died in speed related crashes. Yet, the evidence of speed limits having a significant effect on fatalities is mixed. Ashenfelter and Greenstone (2002) report that fatalities per mile decreased by 15% immediately following the passage of the 1974 EHECA, which restricts speed limits to 55 mph nationwide. The National Research Council publication *Highway Statistics* (1994) reports that the nationwide speed restriction prevented 3,000 to 5,000 traffic fatalities annually. Fatalities were thought to increase when the restriction was lifted on rural highways in 1987. However, Lave (1990) finds the increase in speed limits may have *saved* 3,113 lives between 1987 and 1988. Further, Moore (1999) finds the 1995 repeal of the nationwide speed limit on urban highways led to 66,000 *fewer* road injuries in 1997 than in 1995.

Helmet Laws

In 1967, the federal government encouraged states to adopt universal helmet laws by making the issue a stipulation to qualify for federal safety programs and highway construction funds. The universal helmet law requires all riders, regardless of age, to wear a helmet. In the early 1970's, most states had adopted a helmet law with the exception of Michigan, which repealed the law in 1968. In 1976, Congress removed the mandate requiring states to have helmet laws in order to receive federal highway funds. By 1980, most states had repealed the helmet law or stipulated partial coverage laws, which would only apply to young riders (18 years old and younger). Currently, all but 3 states (Illinois, Iowa, and New Hampshire) have helmet laws. Since 1997, Arkansas, Florida, Kentucky, Pennsylvania, and Texas have moved from universal to partial helmet laws. In 2004, Louisiana moved from a partial to a universal helmet law. Figure 3 summarizes current helmet laws by state. The changes in helmet law adoption and type between states have created a natural experiment used by researchers to study the effects of these laws on helmet use, fatalities, and demand (Dee 2009; Liu et. al. 2008; Sass and Zimmerman 2000).

Seat belt Laws

In 1984, New York was the first state to require front seat occupants to wear a seat belt. As seen in Figure 4, mandatory seat belt laws are currently present in every state with the exception of New Hampshire.[7] In 30 states, the seat belt law is a primary law implying that police officers may stop a vehicle solely because the occupants are not wearing seat belts. In the remaining states, where belt laws are considered secondary laws, a police officer must first have an alternative reason to stop a vehicle prior to giving a seat belt citation. Since 1993, 23 states have moved from a secondary belt law to a primary belt law. The average fine is $32 with five states issuing the lowest fine of $10 and Texas issuing the highest fine of $200. Cohen and Einav (2001) use data from 1983 to 1997 for all 50 states and the District of Columbia to estimate the effectiveness of seat belt laws to reduce fatalities. The authors find that a 10% increase in seat belt usage decreases automobile fatalities by about 1.35% or 500 lives annually.

3. Data

[7] These laws cover front-seat occupants only, although belt laws in 21 states and the District of Columbia cover all rear seat occupants as well. See Figure 4 for current belt laws by state.

The 1984 National Organ Transplant Act (NOTA) established the Organ Procurement Transplantation Network (OPTN) a network of 57 Organ Procurement Organizations (OPO) located in 37 states and the District of Columbia. These OPO's are given monopoly rights to receive and transplant organs within a designated service area. The OPTN has maintained organ donation data collected from each OPO since 1988.[8] Both individual level and OPO level data are available, but only the OPO level data have geographic information on organ transplant. We use the OPO level data to link state traffic laws with OPO locations. This paper uses kidney donation counts from 1988 – 2008 with respect to cadaveric donors and living donors.[9] The OPTN records the state of origin for each organ used in a transplant at an OPO. Each year we observe kidney donations from 46 states (data are missing for Alaska, Montana, Idaho, and Wyoming) for a total of 966 state-year observations.[10] Living donors are disaggregated into biological and non-biological donors.

As illustrated in Figure 1, the number of living donors has increased dramatically over the last twenty years. Perhaps more interestingly, the percent of living donors who are not blood relatives to the organ recipient has also increased from roughly 7% in 1988 to 40% in 2008. One reason for the increase is a change in the surgical procedure used to harvest the kidney. Prior to the introduction of laparoscopic surgery, a 4 to 7 inch incision was needed to retrieve the kidney, which would significantly increase the pain and recovery time associated with the procedure. According to Schweitzer et. al. (2000), the use of laparoscopic surgery has decreased hospital recovery time from four and a half days to three days and has allowed

[8] The OPTN publicly provides these data on their website www.OPTN.org. Both individual level and OPO level data are available, but only the OPO level data have geographic information.
[9] Both Howard (forthcoming) and Dickert-Conlin, Elder, and Moore (2009) use the OPO level data to exploit geographic variation in donations rates, but these studies use a shorter panel than the sample used in this paper.
[10] Organ donation data is available for Washington, DC, but demographic information over the time range 1988-2008 is missing.

donors to return to work 27 days faster. Clearly, this medical advancement decreases the non-pecuniary cost of donating an organ for a living donor. These costs reductions are also a source of savings to the organ recipient (i.e. a decrease in lost wages).

A second reason to observe an increase in non-related donors is the relaxing of donor-donee match requirements. Previously, organ transplants would only occur between biological partners (typically siblings), but today we observe transplants occurring between non-related individuals with the same blood type. This change in policy greatly expands the set of qualified organ donors for a given organ recipient.

While NOTA stipulates it is unlawful to provide financial compensation to the donor, the ordinance does allow for payment to cover expenses directly incurred by the organ donor for the purposes of the donation, like travel costs and lost wages.[11] These non-medical costs are not covered by insurance. Instead, these costs are paid out-of-pocket. By reducing time away from work, compensation associated with lost wages is also decreased. This incentive can potentially establish a link between non-biological donors and disposable income. The U.S. Bureau of Economic Analysis provides data on State Disposable Income Per Capita. The income data are inflation-adjusted to the base year of 2000. We use these data to test if the increase in non-biological donors is affected by higher levels of disposable income.

For each state, we collect information on helmet laws, seat belt laws, and speed limits from the Insurance Institute of Highway Safety. State population, health insurance coverage, race/ethnicity, gender, and age distribution data are gathered from the US Census. Information on marital status and obesity are gathered from the Behavioral Risk Factor Surveillance

[11] Medical expenses for the donor are covered by the donee's insurance. About 80% of the transplant cost is covered by Medicare and the remaining 20% is covered by private insurance.

System.[12, 13] In an effort to control for the effects of religion on organ donations, we collect data on church membership for Catholicism, Judaism, other religions, and atheist from the Association of Religion Data Archives: Churches and Church membership in the United States Decennial survey (1980, 1990, 2000).[14] We also gather race and gender information from the Compressed Mortality files 1988-2006 for non-medical injury deaths to control for demographic differences between the living population and the recently deceased population. Non-medical injury deaths, such as suicide, are a source of cadaveric donors as organs a typically not damaged due to medication or disease.

Descriptive statistics for the primary variables of interest (organ donations, traffic safety laws, and obesity rates) are found in Table 1. Over the entire sample, cadaveric donors, on average, outpaced living donors by a ratio of 5 to 4, but the number of living donors exceeded the number of cadaveric donors from 2000-2005. Within living donors, 73% are from biological donors, 57% of living donors are female, 45% are between the ages of 35-49, and 36% are between the ages of 18-34. Among cadaveric donors, 60% are male, 10% are 11-17 years old, 30% are 18-34 years old, 26% are between 35-50 years old, and 28% are greater than 50 years old.

[12] Marital Status data are missing for less populated states between 1988-1994. This reduces the sample to 933 state year observations.
[13] US Obesity Trends by State from 1985 – 2008 http://www.cdc.gov/obesity/data/trends.html (last accessed June 2009). 21 observations are lost due to missing obesity data for Arkansas, Colorado, the District of Columbia, Maryland, New Jersey, and Pennsylvania in a few years.
[14] Linear interpolations are used to fill in missing values between survey years.

Obesity and end-stage renal disease prevalence rates are collected from the CDC. Obesity rates in the U.S. have risen steadily since the 1990's. By definition, an obese individual has a Body Mass Index (BMI) of 30 or greater.[15] According to the CDC:

> 10 states had a prevalence of obesity less than 10% and no states had prevalence equal to or greater than 15% in 1990. By 1998 no state had a prevalence of obesity less than 10%. In 2007, only one state (Colorado) had a prevalence of obesity less than 20%. Thirty states reported a prevalence rate equal to or greater than 25% and three states (Alabama, Mississippi and Tennessee) had a prevalence of obesity equal to or greater than 30%.

Over the same time period, living donations increased by 197% and cadaveric donations increased by 69%. We find that 81% of the states in our sample report obesity rates between 10%-24%.

Next, we analyze data on traffic safety laws. Most states have laws requiring helmet use on motorcycles and seat belt use in motor vehicles (see Figures 2-3). There exist two variants for each type. In reference to helmet use, there is a full helmet law requiring all passengers to use a helmet when riding a motorcycle and a partial law only requiring young passenger (18 years or younger) to wear a helmet. Similarly, the primary seat belt law allows police officers to stop motor vehicles and issue fines when seat belts are not in use, but secondary seat belt laws only allow for fines when drivers are stopped due to a different traffic violation.

Large variations in helmet and seat belt laws between states are observed. This is expected due to the many adoptions, repeals, and modifications to these laws during the period of our sample. On the other hand, speed limits display little variation as 56% of the states report rural speed limits equal to 65 mph and 57% report urban speed limits of 55 mph or less. As observed in Figure 2, maximum speed limits have regional tendencies such as being lower

[15] Body Mass Index (BMI) is calculated as a person's weight in kilograms divided by the square of his/her height in meters. BMI is not a perfect measure for obesity as it fails to account for muscular mass versus fat.

in the Northeastern region and higher in the Western region. The majority of speed limit changes occurred shortly after the 1987 modification to the EHECA and the 1995 repeal.[16]

In addition to the variables of interest, a secondary set of control variables are collected. The descriptive statistics for these variables are found in Table 2. These control variables can be grouped into the following categories: race/ethnicity, gender, age, marital status, religion, health insurance, and income. The demographic variables (gender, age, race/ethnicity, and marital status) capture unobserved effects that are specific to these sub-populations. The race and age variables are further disaggregated into two sub samples, the living population and recently deceased population. This allows difference in race and age composition between the living and the deceased to affect the supply of cadaveric kidney donors. The religion variables are intended to capture the effects of religious beliefs on organ donations. Although no organized religion in the western hemisphere officially discourages organ donations, some religious groups may hold private beliefs that either encourage or discourage participation in organ transplants.[17]

The health insurance variables can affect organ donations in two ways. First, if a greater percentage of the population has health insurance, then an individual's health is less likely to deteriorate such that an organ transplant is necessary. Second, in the event an organ transplant is necessary, individuals with alternative forms of health insurance can cover the costs of transplants not paid by Medicare.[18]

4. Model and Results

[16] These events present a problem during estimation in that the use of year fixed effects may confound the effect of speed limit changes.

[17] See the following article for more information: SEOPF/UNOS, Organ and Tissue Donation: A Reference Guide for Clergy, 4th ed., 2000. Cooper ML, Taylor GJ, eds. Richmond, VA

[18] All organ transplant recipients have 80% of their cost covered by Medicare regardless of age.

Consider the following conceptual model based on living donors being altruistic. A living donor's utility function takes the form of

$$(1) \qquad U(H, a, c, p) = \max[H + a * p * U(CD)_{donee}, H - c + a * U(LD)_{donee}]$$

where 'H' represents the donor's Health, 'c' is the cost to health for donating an organ, p is the probability the organ recipient receives an organ from a cadaveric donor, 'a' is the level of altruism the donor has for the organ recipient. According to The National Kidney Foundation's Fact Sheet, patients receiving a kidney from a living donor (LD) have a 1 year survival rate of 97.9% versus a 94.4% survival rate when a kidney from a cadaveric donor (CD) is used.[19] For this reason, we assume an organ recipient's utility is higher when receiving an organ from a living donor, U(LD)>U(CD). In relative utility, the potential donor chooses not to donate if $c > a[U(LD)_{donee} - pU(CD)_{donee}]$ or the cost of donation is greater than the relative expected benefit of supplying an organ from a living donor. A potential donor faces several cost including pain associated with the procedure, lost wages due to time away from work for the procedure, and potentially lower lifetime income due to a lower lifetime level of health. Advancements in medicine can decrease these costs over time leading to an increase in the supply of living donors, *ceteris paribus*.

Altruism plays an important role in this model. For our purposes, altruism is captured by allowing the donor's utility to be dependent upon the donee's utility. The magnitude of 'a' in the donor's utility becomes larger the more familiar a donor is with the organ recipient. Altruism creates a positive supply of organs at a price of zero.[20] The probability of receiving a cadaveric organ, p, is dependent on the size of the waiting list and the level of altruism in

[19] Additionally, kidney grafts from living donors have a 95.1% survival rate versus 89% for grafts from cadaveric donors.
[20] See Epstein (2008) for a discussion on the effects of altruism on organ supply.

society associated with donating organs at death. As the waiting list increases, *p* decreases, thereby encouraging more living donations. If the level of altruism among cadaveric donors rises in society, then *p* increases and causes living donor rates to marginally decrease. On the other hand, if altruism rises among living donors, then the number of living donors rises. In an effort to increase altruism among potential living donors, websites such as livingdonors.org and matchingdonors.com provide information pertaining to patients in need of an organ. These websites can increase living donor rates by personalizing organ matches; thereby increasing altruism on the part of the donor, $`a' \; increases$.

In the conceptual model, the organ donor is the end decision maker, but in reality several agents may affect the decision. For example, the transplant physician serves as the agent for the organ recipient who is the principle. A principle-agent problem arises as the physician must not only consider the health of the patient, but also the health of other patients on the waiting list. Therefore, the physician may determine that the patient is not of good health and thus receives less priority to the organ (Mandelbrot, 2007). The principle may also refuse a living kidney donation because they do not wish to impose a cost to a donor with whom they are familiar (Pradel et al 2003).

The duality of altruism in the organs market plays an important role when estimating the substitution effect between living and cadaveric donors. Higher levels of altruism in a state will increase the number of the cadaveric and living donations regardless of the substitution effects. Unfortunately, the level of altruism is an unobserved variable and would cause least squares estimates of the substitution to be biased. An instrumental variables approach is used to remove the endogeneity bias caused by unobserved altruism.

The substitution effect of cadaveric donors for living donors is estimated using 2SLS where traffic safety laws serve as instruments for the supply of cadaveric organs. Traffic safety laws function as exogenous shifters to the supply of cadaveric donors. These instruments are independent of altruism among organ donors.

The primary equation of interest is the living donor equation

$$LD_{st} = \alpha CD_{st} + \theta Obesity_{st} + X_{st}\beta + \delta_s + \varepsilon_t + v_{st} \tag{2}$$

where *s* indexes state, *t* indexes year, LD_{st} measures living kidney donors per 100,000 individuals in the state, CD_{st} are cadaveric donors per 100,000 individuals in the state, X_{st} is a matrix of socio-demographic variables (including race/ethnicity, health insurance coverage, age, gender, marital status, state disposable income per capita, state population, and religion), and *Obesity* is a continuous variable measuring the percentage of the state population that is obsess (BMI ≥ 30).

The error term captures all unobserved changes within a state and across time associated with living donations. These unobserved measures may include variation in the causes of hospital deaths, changes in medical technology, changes in physician/hospital practice in regards to organ transplants, and differences in altruism. We adopt a fixed effect specification where δ_s is a state specific fixed effect, ε_t is a year specific fixed effect, and v_{st} is an idiosyncratic state-year shock with mean zero and finite variance.[21] Given the monopolistic and regulated nature of the OPO's, this specification controls for unobserved changes in nationwide organ procurement policy and procedure via the year dummy variables.

[21] We also consider an autoregressive error, but do not find any evidence that either living or cadaveric donations follow a random walk or explosive process.

A variable missing from our specification is the current size of the organ waiting list. Naturally, potential living donors would consider the current shortage of kidneys in their designated organ market before deciding to donate, but this variable is econometrically endogenous. In a typical goods market, both price and quantity are determined by the intersection of the demand and supply curve. These variables are determined within the model, thus both are econometrically endogenous. In the organs market, price is restricted to be zero. The endogenous variables determined by the model become the quantity demanded and the quantity supplied when price is equal to zero. The size of the waiting list is the difference between these two endogenous variables, therefore it too is endogenous. For this reason, we forgo using the size of the organ waiting list as an explanatory variable in the living organ donations equation.

Tables 3 contain ordinary least squares estimates of the parameters θ, β, and α under different model specifications. In Table 3, the first column provides estimates including variables found in all years and states of the sample. The second column includes marital status and the third column includes a quadratic term for the obesity variable. Across the three specifications, we find a positive point estimate for the effect of cadaveric donations on living donations, but these estimates are not found to be different from zero at conventional levels of significance.

Similarly, the obesity coefficients are all positive, but indistinguishable from zero in the first two columns. In column 3, we follow Sleck, Deb, and Grossman (2008) and consider non-linear effects of obesity by including a quadratic obesity term. This specification does yield a statistically significant effect of obesity on living kidney donations at the 10% level. Living donations are found to increase as the state's population becomes more obese, but at a decreasing rate among relevant values of the obesity variable (the maximum occurs at an obesity rate of 112%). A concern of using obesity in this analysis stems for the potential that obesity is correlated with unobserved state specific health shocks. We attempt to minimize this concern by including prevalence rates for end-stage renal diseases as a secondary measure of health. This variable is disaggregated into patients with diabetes and those without. Both variables are found to be significant at the 1% level where an increase among non-diabetic (diabetic) prevalence of ESRD is found to increase (decrease) living kidney donations per 100,000 individuals.

Other notable observations are that the divorce percentage and Medicaid percentage are found to decrease living donor rates in all specifications. These two variables are statistically significant at the 1% in all specifications using state and year dummy variables. A 1% increase in divorce (Medicaid enrollment) decreases living donor rates between -0.03 to -0.07 (-0.06 to (-0.07). Lastly, we do not observe a link between living organ donations and disposable income. All point estimates of income per capita are found to be positive, but none are statistically significant at conventional levels.

The previous regressions treat the supply of cadaveric donors as exogenous, but the positive correlations between living and cadaveric donations observed in these regressions may be the result of both variables being positively correlated with unobserved altruism. As a result, these coefficients may be biased. Two potential solutions can correct the econometric bias: (1) using a proxy variable for altruism or (2) using valid instruments for cadaveric donations that are independent from state specific altruism. An ideal proxy variable would be a measure of charitable contributions or blood donations made by all individuals in a state, but data for these variables are typically only available for the subset of the population that makes a charitable contribution and thus suffers from a sample selection bias.[22]

Instead, we utilize an instrumental variables approach to remove the bias. We propose the following specification for the supply of cadaveric donations per 100,000 individuals

$$CD_{st} = \delta(law_{st}) + \lambda W_{st} + \delta_s + \varepsilon_t + v_{st} \quad (4)$$

where CD_{st} represents cadaveric kidney donations per 100,000 individuals in the state, law_{st} is a matrix of dummy variables capturing changes in traffic safety laws (full and partial helmet laws, primary and secondary seat belt laws, rural highway speed limits, and urban highway speed limits), and W_{st} is a matrix containing the age distribution of recently deceased individuals in a state who died as a result of a non-medical injury. These individuals are the most likely candidates for organ donation as their organs are not typically damaged, due to diseases such as cancer.

In order to gauge the strength of these instruments, we first estimate equation (4) using four different specifications. Each specification progressively adds more instrumental variables in the following order: helmet laws, speed limits, seat belt laws, and injured death demographics. For each specification, the incremental F-statistics testing the validity of the instruments is calculated. These estimates can be found in Table 4. The proposed instruments are found to be strongly correlated with the supply of cadaveric donors as indicated by the F-stat ranging from 5.09 to 16.18.[23] Both helmet laws are found to reduce the supply of cadaveric donors by a range of (-0.63, -1.24) donations per 100,000 in models OLS 4 – OLS 7. A universal helmet law, not surprisingly, has a larger effect than a helmet law that target young

[22] We attempted to use average contributions per tax return as a proxy for altruism, but found no effect on living kidney donations.
[23] As a rule of thumb, an F-stat of 10 or greater indicates strong instruments (Stock et. al. 2002).

drivers. These results are consistent with the findings of Dee (2009) and Dickert-Conlin, Elder, and Moore (2009). On the other hand, the supply of cadaveric donations is increasing as the speed limit on rural highways increases. An increase in the speed limit from 55 mph to 60 mph increases the number of cadaveric donations, on average, by 1.2 donations per 100,000 and is statistically significant at the 1% level. The effect of urban speed limits is mixed. At lower speed limits, cadaveric donations are found to decrease, but these effects disappear at speed limit in excess of 65 mph. Seat belt laws are not found to have an effect on cadaveric donations given conventional levels of significance.

Given the strength of the proposed instruments, we proceed by estimating the living donor equation using 2SLS. The 2SLS estimates are found in Table 5. Each specification adds additional instrumental variables to the first stage regressions as is done in the previous section. In all four specifications, we find a negative relationship between living and cadaveric donations. Living donations are found to decrease between -0.2 to -0.6 donations per 100,000 for one additional cadaveric donation per 100,000 and all the estimates are at least significant at the 10% level.[24] These estimates are in full agreement with those found in Howard (forthcoming). From these estimates, we infer the elasticity of substitution to be between -0.36 and -0.54 when evaluated at the mean of living and cadaveric donations per 100,000.[25] This result is important when considering measures to increase the supply of cadaveric donations. The elasticity estimates indicate that the level of living donors would decrease when an expansionary policy (such as an opt-out policy for donations) is adopted, but the overall effect is an increase in the supply of kidney donations. We also perform robustness test by adding

[24] Not shown here, these results still hold after first-differencing the data to control for any autoregressive shocks in the error term.

[25] Elasticity can be evaluated at the mean as $\varepsilon = (\frac{\delta y}{\delta x})\frac{x}{y}\Big|_{x=\bar{x},y=\bar{y}}$

marital status and quadratic specifications of obesity into the second stage regression. There are no significant changes in the substitution effect. These results are also robust to different specification of the error term including an AR(1) process and a random effects model.

Obesity is not found to have a direct effect on the supply of living donations in most specifications. Further, the exclusion of the obesity variable does not affect the substitution effect estimate significantly. However, when a quadratic term is included in the obesity specification there are significant effects on both living donations (positively) and cadaveric donations (negatively) at the 5% level, but the effects are small. On average, a 1 percent increase in the prevalence of obesity increases (decreases) living (cadaveric) donations by 0.02 (0.01) donations per capita.

On the other hand, the prevalence of end stage renal disease (ESRD) does have a significant effect on both living and cadaveric donations. We disaggregate the ESRD variable into two groups, diabetic and non-diabetic patients. Although both patient groups are unhealthy, the diabetic group is composed of individuals with a poorer health state. In all specifications, non-diabetic ESRD prevalence is found to have a positive effect on both types of kidney donations at the 1% level. On average, an increase in non-diabetic ESRD prevalence of 100 patients increases both living and cadaveric donations by 0.2 to 0.5 donations. However, an increase of 100 diabetic ESRD patients per million decreases both types of donations by 1 to 2 donations per 100,000 individuals and is significant at the 5% level. These results are consistent with Howard (2002; forthcoming) and Sweeney (2010) where relative health is an important determinant to receive an organ.

Several other variables are found to have statistically significant effects on the level of living kidney donations at the 10% level. Living donations are found to increase as the percentage of African-Americans rises. Yet, it is not clear from this result if African-Americans are more likely to donate an organ or are more likely to receive an organ when this percentage rises. The level of living kidney donations also increases as the percentage of older citizens (75 years or older) increases. Potentially, the likelihood of needing an organ transplant is highest among this group as health depreciates with age. Neither marital status nor income per capita are found to have a statistically significant effect on living donations.

With respect to religion, a 1% increase in the population of Catholics or Jews relative to atheist decreases living kidney donations. by -0.05 donations and -0.3 donations per 100,000 individuals, respectively. Yet, an increase in the percentage of other religious groups does not have a significant effect on living donations. Next we examine health insurance coverage and find that any type of health insurance decreases living donations, but the effect is only statistically significant with respect to Military coverage and Medicaid coverage. Access to health insurance provides individuals with alternative forms of treatment or methods to delay the need for an organ transplant. On the other hand, individuals without health insurance may only seek medical services once their health has been severely affected. On average a 10% increase in health insurance coverage decreases the level of kidney donations by -0.5 donations per 100,000 individuals.

Last, we turn our attention to non-biological living donors. The use of laparoscopic surgery to remove kidneys has greatly reduced pain and recovery time for living donors. In addition to the reduction of these non-pecuniary costs, this procedure has allowed donors to return to work faster leading to fewer lost wages.[26] Additionally, the match requirements necessary for organ transplants have relaxed over time. These two changes decreased transaction costs and increased the supply of living donations from non-biological donors.

This section further investigates the relationship between living and cadaveric donors and tests whether the substitution patterns identified in the previous sections hold for all sub-groups of living donors or only a few. To this end, we disaggregate the living donor variable into biological donors and non-biological donors. We further disaggregate non-biological donors into anonymous donors and spouse or unrelated known donors. The previous instrumental variable equations are re-estimated for each of these sub-samples.

For brevity, we focus our discussion on the substitution effects between the sub-groups of living donors and cadaveric donors. The first column of results in Table 6 provides point estimates of the substitution effect with respect to biological donations per 100,000 individuals. In all specifications, the point estimates are found to be indistinguishable from zero at conventional levels. Biological donors appear to be insensitive to changes in the supply of cadaveric donors. A few reasons may cause this result. First, search and transaction costs may be smallest for biological donors. These donors are typically easier to locate and more likely to be good matches for the organ recipient. Next, these donors place the highest weight on the utility of the organ recipient within their own utility function. Therefore, they are less likely to risk losing their relative by waiting for a cadaveric organ donor.

On the other hand, non-biological donors are found to be sensitive to changes in the supply of cadaveric donors. The substitution elasticity ranges from -1.30 to -1.58 (point

[26] Although not covered by public or private insurance, NOTA does allow donors to be compensated for travel, lost wages, child care, and other expenses that are directly related to the transplant procedure.

estimates between -0.19 to -0.23) and the point estimates are statistically significant at the 1% level. When we disaggregate non-biological donors into anonymous donors and non-blood relatives (i.e. spouses and friends) we find, surprisingly, that anonymous donors are not found to respond to shifts in the supply of cadaveric donors. On the other hand, non-biological donors who are known to the organ recipient have elasticity (point) estimates equal to -1.59 (-0.21), on average. All point estimates for this group are statistically significant at the 1% level.

These results are consistent with surveys performed by Mandelbrot, D.A. et. al. (2007) and Pradel et. al. (2003). A potential cause for these results is that non-biological donors are more sensitive to changes in the cost of donating than biological donors. The relative cost of donating may be smaller for biological donors as there is a higher probability that their organ is a more suitable match. Yet, the difference between the two effects remains large when considering that the requirements for donation eligibility have been reduced over time. A secondary cause stems from the organ recipient forgoing living donations from known sources for fear of harm to the donor (Kranenburg et al. 2007; Kranenburg et al 2009; Young et al 2008). This would explain the relative difference between known non-biological donors and anonymous donors.

One caveat of these results is the exclusion of paired transplants and transplant chains in the disaggregated living donor analysis. Paired transplants occur when two individuals in need of two different organs are capable of trading organs to one another (ie liver for kidney). A transplant chain may occur when organ recipient 1 has an organ donor who is not a good match for them, but may be a good match for a different organ recipient (recipient 2). In turn, recipient 2 must be capable of supplying the necessary organ to recipient 1. The absence of these individuals changes the magnitude of the estimated substitution effect between the aggregate group and the sub-groups.

5. Conclusion

The organ shortage discussion is full of suggestions on alleviating the problem, but little empirical evidence exists to evaluate the magnitude of these suggestions or to measure how living donors will react to changes in incentives. In this paper, we consider how the supply of living kidney donations reacts to changes in the supply of cadaveric donations. To this end, we propose a model to estimate the substitution patterns between living and cadaveric donations while controlling for the effects of unobservables, such as altruism, on these variables.

Currently, the organs market is regulated such that trades take place at the price of zero. For a market to exist at this price there needs to be a population of altruistic individuals willing to donate. Therefore, both living and cadaveric donations are positively correlated with altruism. The potential of an econometric bias when estimating the effect cadaveric donations on living donations exists because altruism is unobserved by the econometrician. Failing to control for altruism may lead researchers to conclude that the number of living donors and cadaveric donors are positively correlated. We propose using traffic safety laws as instruments for the supply of cadaveric donors. Many of these laws are initially adopted by states because the federal government tied federal highway maintenance/construction funds to these laws. Therefore, these laws were neither adopted to affect altruism levels in the state, nor to manipulate the supply of cadaveric/living organ donors.

Utilizing variation in traffic safety laws as instruments for the supply of cadaveric donors, the 2SLS estimates find that one additional cadaveric kidney donor per 100,000 individuals decreases living donors by -0.2 to -0.3 donations per 100,000 per year or an elasticity of substitution between -0.36 to -0.54. This finding suggest that an expansionary policy for cadaveric donations such as an assumed consent policy would decrease the level of living donors, but would still increase the level of organ donations overall.

Among living donors, biological and unrelated anonymous donors are found to be insensitive to changes in the supply of cadaveric donors, but related non-biological donors (ie spouses and friends) are found to be responsive to shifts in the supply of cadaveric donors with an elasticity of substitution equal to -1.59.

Although further research is necessary, understanding the trade-offs faced by living donors is important to allow for more informed policy choices. Less than 1 percent of hospital deaths are suitable for organ transplant.[27] The organ shortage will not be resolved through cadaveric donations alone, but rather in conjunction with living donations. Currently, compensation for organs is considered unlawful, but a potential alternative may come in the form of a tax incentive. The Organ Donation and Recovery Improvement Act (H.R. 3926), which was signed into law on April 5, 2004, has a provision allowing states to offer tax deductions for organ donors. As of this paper, 12 states have adopted tax deductions of up to $10,000, and another 18 are considering similar ordinances.[28]

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[27] A majority of hospital deaths leading to organ donation are associated with brain dead patients, but there are currently new developments to increase the number of donations from patients who die of cardiac arrest. See http://www.organtransplants.org/understanding/death/ (last accessed June 2009)

[28] Arkansas, Georgia, Iowa, Louisiana, Minnesota, Mississippi, New Mexico, New York, North Dakota, Ohio, Oklahoma, Utah, and Wisconsin have adopted tax deductions for organ donations. Hawaii, Idaho,

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Glossary and Source of Data

Health Insurance

Source: US Census – Health Insurance Historical Tables 1988 – 2008
www.census.gov/hhes/www/hlthins/historic/hihistt4.xls

Variables
% No Insurance = percent of state population without health insurance
% Private Insurance = percent of state population with employer or direct purchase health insurance
% Medicaid = percentage of the state population receiving Medicaid coverage
% Medicare = percentage of the state population receiving Medicare coverage
% Military = percentage of the population receiving veterans or active military coverage.

State Demographics: Religion

Source: Churches and Church Membership in the United States (1980), Churches and Church Membership in the United States (1990), Religious Congregations and Membership Study (2000) via the Association of Religion Data Archives (ARDA).

Variables by state*
% Catholic = percentage of survey respondents who identify themselves as Catholic
% Jewish = percentage of survey respondents who identify themselves as Jewish
% Other = percentage of survey respondents who identify themselves as a member of an organized religion other than Catholicism or Judaism.
*= linear interpolation is used to produce values for missing years; the variables need not add up to unity as some respondent claim to not be part of organized religion or be an atheist.

State Demographics: Marital Status and Obesity

Source: Behavioral Risk Factor Surveillance System (BRFSS) 1988-2007

Variables by State

Married = percentage of the sample who are married
Divorced = percentage of the sample who are divorced
Separated = percentage of the sample who are separated, but still married
Single = percentage of the sample who are single
Partnered = percentage of the sample who are partnered
Obesity = percentage of the sample with BMI greater than or equal to 30.

State Demographics: Age Race/Ethnicity, and Population

Source: US Census Annual Population Estimates and Characteristics 1988 – 2008
http://www.census.gov/popest/states/states.html (last accessed June 2009)

Variables by State
Age: Percentage of state population within a 5 year age bracket from 0 to 85 years.
Population: state population by year

State Demographics: Age, Race, Gender, and Population of Deceased by state

Source: Compressed Mortality Files by State 1988 – 2006
http://wonder.cdc.gov/mortsql.html (last accessed June 2009)

Variables by state *
% White = percentage of deaths who are white
% Black = percentage of deaths who are black
% Hispanic = percentage of deaths who are Hispanic
% Asian = percentage of deaths who are Asian
% Other = percentage of deaths who are Other
Age = number of deaths within a 5 year age bracket from 0 to 85 years
% Female = percentage of deaths who are Female.
* = only deaths resulting from injury (non disease) are considered. Injury deaths are the most likely candidates for organ donations as the organs themselves may not contain diseases such as cancer that would impede an organ transplant.

Traffic Safety Laws: Helmet Laws, Seat belt Laws, and Speed limits by State
Source: Insurance Institute for Highway Safety and Highway Loss Data Institute 1998 – 2008 www.iihs.org/laws/ (last accessed June 2009)

Variables by state
Full Helmet = A binary variable taking the value of 1 if a full helmet law requiring all passengers to wear a helmet is enforced and zero otherwise.
Partial Helmet = A binary variable taking the value of 1 if young passengers (18 years old or less) are required to wear a helmet and zero otherwise.
Primary Seat belt = A binary variable taking the value of 1 if a motorist can be stopped and ticketed for not wearing a seat belt and zero otherwise.

Secondary Seat belt = A binary variable taking the value of 1 if a motorist can be ticketed for not wearing a seat belt after being stop for an alternative traffic infraction and zero otherwise.
Urban Speed Limits = a set of dummy variables capturing changes in speed limit laws for 50 mph, 55 mph, 60 mph, and 65 mph.
Rural Speed limits = a set of dummy variables capturing changes in speed limit laws from 55 mph, 60 mph, 65 mph, 70 mph, and 75 mph or greater.

Organ Donation Data

Source: Organ Procurement Transplantation Network www.OPTN.org

Figure 1

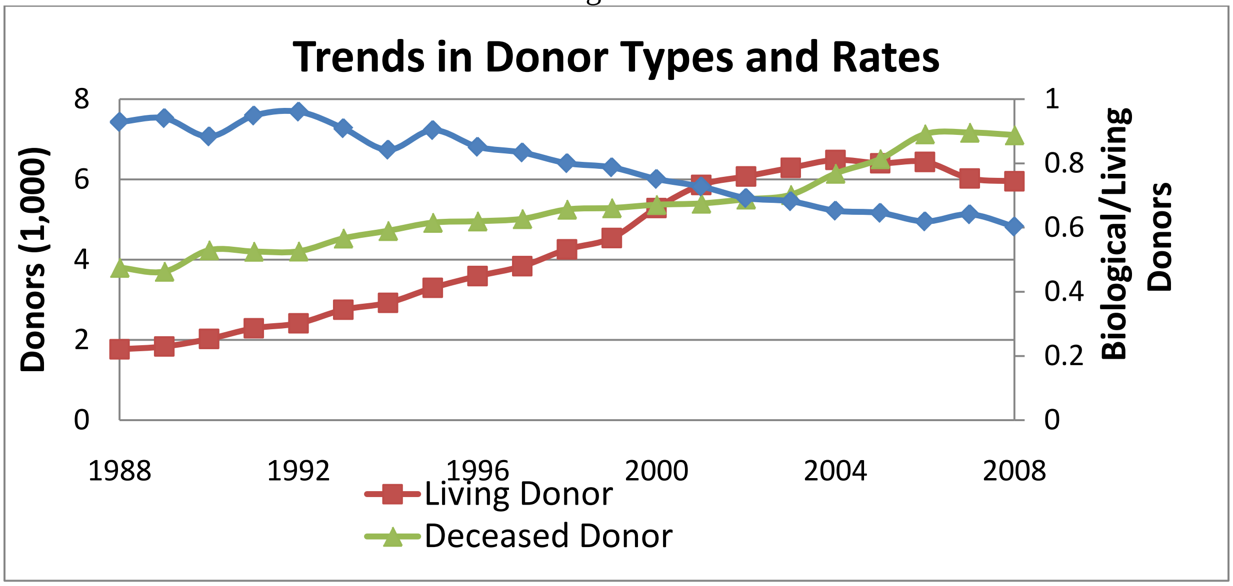
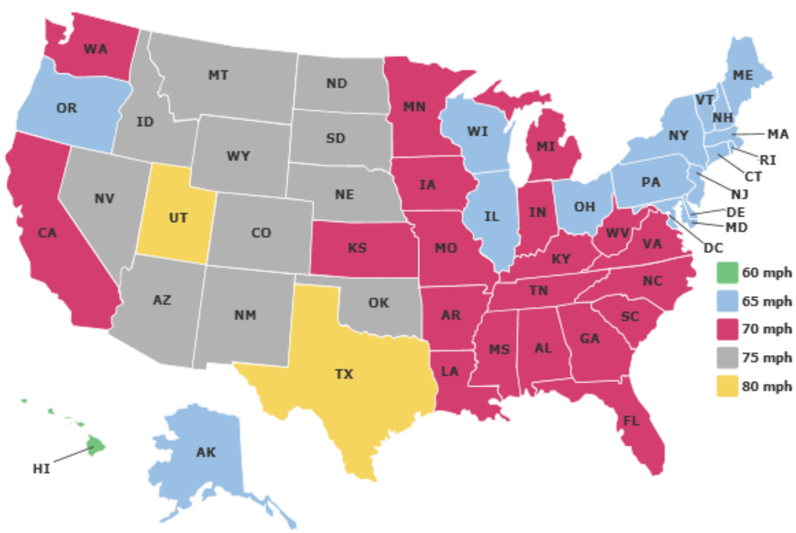


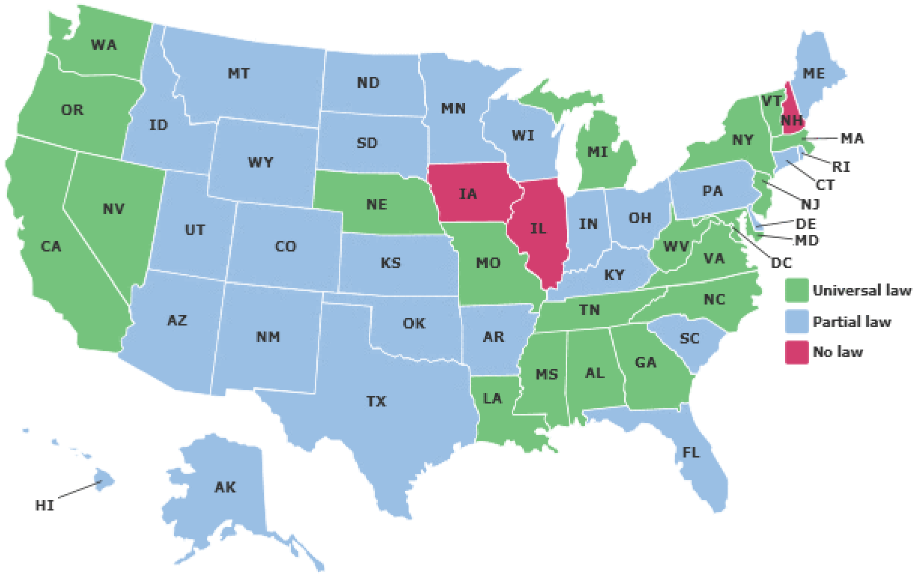
Figure 2: Maximum Rural Highway Speed Limit by State



Note:

1) Source: Insurance Institute for Highway Safety
http://www.iihs.org/laws/mapmaxspeedonruralinterstates.aspx
2) Maximum limit may apply only to specified segments of interstate.

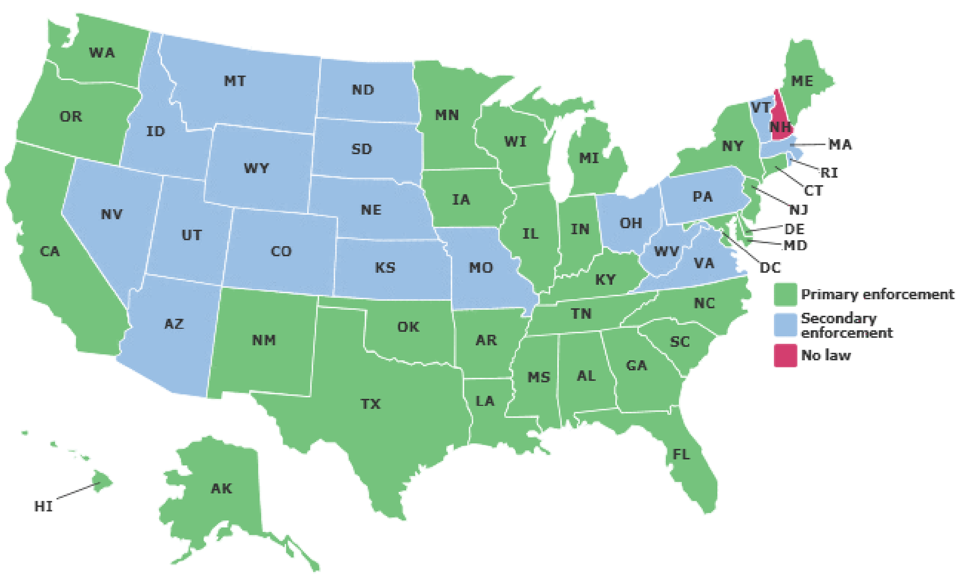
Figure 3: Motorcycle Helmet Laws by State



Note:

1) Source: Insurance Institute for Highway Safety http://www.iihs.org/laws/HelmetUseCurrent.aspx#IA
2) Universal coverage requires that all riders wear helmets
3) Partial coverage states that riders under an age determined by the state are required to wear helmets

Figure 4: Seatbelt Laws by State



Note:

1) Source: Insurance Institute for Highway Safety http://www.iihs.org/laws/HelmetUseCurrent.aspx#IA
2) Primary enforcement stipulates that a vehicle may be stopped solely for this offense.
3) Secondary enforcement stipulates that an additional fine may be assessed after stopping the vehicle for a different violations granted that the passengers are not wearing their seat belts

Table 1: Summary Statistics for Donation Types, Obesity Levels, and Traffic Safety Laws

Variables	Mean	STD	Min	Max	N
Living Donors	93.72	113.89	0.00	743	966
Living Donors per 100,000	1.51	1.11	0.00	8.07	966
Cadaveric Donors	177.73	205.15	0.00	1292	966
Cadaveric Donors per 100,000	2.74	1.09	0.00	7.13	966
Biological Donors	68.80	79.45	0.00	500	966
Biological Donors per 100,000	1.11	0.74	0.00	5.54	966
ESRD Prevalence (non-diabetic)[1]	819.73	172.51	424.02	1261.6	966
ESRD Prevalence (diabetic)[1]	437.06	180.75	101.95	1174.0	966
% Obese (BMI $\geq$ 30)	0.18	0.06	0.06	0.33	966
Secondary Seatbelt Laws	0.60	0.49	0.00	1.00	966
Primary Seatbelt Laws	0.30	0.46	0.00	1.00	966
Helmet Law (Full)	0.47	0.50	0.00	1.00	966
Helmet Law (Partial)	0.42	0.49	0.00	1.00	966
75 mph (rural)	0.11	0.32	0.00	1.00	966
70 mph (rural)	0.22	0.41	0.00	1.00	966
65 mph (rural)	0.58	0.49	0.00	1.00	966
60 mph (rural)	0.04	0.20	0.00	1.00	966
55 mph or less (rural)	0.04	0.21	0.00	1.00	966
75 mph or greater (urban)	0.03	0.18	0.00	1.00	966
70 mph (urban)	0.10	0.29	0.00	1.00	966
65 mph (urban)	0.23	0.42	0.00	1.00	966
60 mph (urban)	0.04	0.19	0.00	1.00	966
55 mph (urban)	0.60	0.49	0.00	1.00	966

Note: Data for Alaska, Idaho, Montana, and Wyoming was unavailable

[1]End-Stage Renal Disease (ESRD) patients alive on December 31 of each year, per million population

Table 2: Summary Statistics for State Demographics

Variables	Mean	STD	Min	Max	N
Living					
- % White	0.77	0.15	0.28	0.98	966
- % Black	0.11	0.09	0.00	0.37	966
- % Hispanic	0.07	0.09	0.00	0.45	966
- % Other	0.05	0.09	0.00	0.61	966
- % Female	0.51	0.01	0.49	0.52	966
- % Married[2]	0.59	0.04	0.23	0.69	933
- % Divorced[2]	0.10	0.02	0.06	0.16	933
- % Widowed[2]	0.08	0.02	0.04	0.17	933
- % Separated[2]	0.02	0.01	0.00	0.08	933
- % Never married[2]	0.18	0.03	0.09	0.42	933
- % Partnered[2]	0.03	0.01	0.00	0.07	933
- Age between 0-19 years old	0.28	0.02	0.23	0.40	966
- Age between 20-34 years old	0.22	0.02	0.17	0.28	966
- Age between 35-54 years old	0.28	0.02	0.20	0.33	966
- Age between 55-74 years old	0.16	0.02	0.11	0.21	966
- Age 75 years old or greater	0.06	0.01	0.03	0.09	966
- % No Insurance	0.12	0.04	0.05	0.24	966
- % Private Insurance	0.64	0.06	0.45	0.77	966
- % Medicaid	0.10	0.03	0.02	0.20	966
- % Medicare	0.12	0.02	0.07	0.18	966
- % Military	0.04	0.02	0.01	0.12	966
- % Catholic	0.20	0.12	0.02	0.63	966
- % Jewish	0.01	0.02	0.00	0.10	966
- % Other Religion	0.30	0.15	0.09	0.76	966
- State Population (100,000)	58.62	60.81	5.50	367.59	966
- State Income Per Capita ($10,000)	2.69	0.55	1.57	5.34	966
Death Due to Injury[3]					
- % White	0.83	0.12	0.29	1.00	874
- % Black	0.13	0.11	0.00	0.43	874
- % Other	0.04	0.10	0.00	0.70	874
- %Female	0.32	0.16	0.00	0.95	874
- Ages between 0 to 19 years old	0.13	0.03	0.05	0.22	874
- Ages between 20 to 34 years old	0.25	0.04	0.14	0.37	874
- Ages between 35 to 54 years old	0.29	0.05	0.17	0.40	874
- Ages between 55 to 74 years old	0.15	0.02	0.10	0.22	874
- Ages greater than 75 years old	0.18	0.05	0.07	0.32	874

Note:
[1]Data for Alaska, Idaho, Montana, and Wyoming are unavailable.
[2]Marital Status is missing for Delaware and RI.
[3]Compressed Mortality File is available for 1988-2006. Only deaths resulting from non-medical injury are used.

Table 3: Least Squares Regression of Living Donor Per 100,000 in State Population

Living Donors Per 100,000	OLS 1		OLS 2		OLS 3	
	β	SE	β	SE	β	SE
Cadaveric Donors Per 100,000	0.01	(0.04)	0.01	(0.04)	0.02	(0.04)
Prevalence ESRD (diabetic)*	-4e-4	(5e-4)	-4e-4	(6e-4)	-2e-4	(6e-4)
Prevalence ESRD (non-diabetic)*	4e-3[a]	(5e-4)	4e-3[a]	(5e-4)	4e-3[a]	(5e-4)
% White	-6.16	(4.15)	-6.94	(4.51)	-5.09	(4.45)
% Black	23.61[a]	(5.57)	24.03[a]	(5.87)	23.91[a]	(5.90)
% Hispanic	6.28	(5.07)	5.29	(5.34)	2.99	(5.55)
% Female	-32.68[c]	(18.71)	-31.01	(19.39)	-35.58[c]	(19.27)
% Obese	0.86	(1.15)	0.99	(1.20)	14.70[a]	(3.47)
$(\% \text{ Obese})^2$					-36.09[a]	(8.98)
Income Per Capita ($10,000)	0.01	(0.03)	0.01	(0.03)	0.01	(0.03)
Population (100,000)	-0.01[a]	(3e-3)	-0.01[a]	(3e-3)	-0.01[a]	(3e-3)
Age: 0 – 19	-30.53[a]	(9.14)	-33.90[a]	(9.74)	-31.13[a]	(9.65)
Age: 20 – 34	-39.51[a]	(8.34)	-41.63[a]	(8.94)	-40.25[a]	(8.78)
Age: 35 – 54	-30.07[a]	(9.37)	-30.93[a]	(9.91)	-32.80[a]	(9.79)
Age: 55 – 74	-24.16[a]	(8.80)	-28.02[a]	(9.53)	-30.43[a]	(9.29)
% Private Insured	-0.81	(1.03)	-0.76	(1.06)	-1.24	(1.06)
% Medicaid	-4.92[a]	(1.29)	-4.69[a]	(1.31)	-5.06[a]	(1.33)
% Medicare	-2.10	(2.03)	-1.47	(2.10)	-1.17	(2.08)
% Military	-2.70	(1.94)	-2.76	(2.00)	-2.48	(1.96)
% Catholic	-2.63[a]	(0.97)	-2.55[b]	(1.00)	-2.67[a]	(0.99)
% Jewish	-18.42[a]	(5.84)	-16.74[b]	(6.52)	-12.43[c]	(6.68)
% Other Religion	1.25[c]	(0.71)	0.74	(0.75)	-0.65	(0.89)
% Married			-0.04	(0.82)	-0.53	(0.82)
% Divorced			-2.24	(1.46)	-2.45[c]	(1.42)
% Widowed			-0.60	(1.57)	-0.97	(1.62)
% Separated			-0.31	(3.39)	-1.01	(3.41)
% Partnered			2.48	(2.32)	1.72	(2.40)
R^2	0.87		0.87		0.88	
No. Observations	966		933		933	
State and Year Fixed Effects	Yes		Yes		Yes	

Notes:
1) All estimation samples consist of 46 states from 1988 to 2008. The unit of observation is state*year.
2) Standard errors are estimated using the Huber/White/Sandwich estimator of variance.
3) Level of Significance: [a] = 1%; [b] = 5%; [c] = 10%
4) All observations are weighted by the state's population in the given year.
5) * signifies End-Stage Renal Disease prevalence per million by state population

Table 4: Least Squares Regression of Cadaveric Donations per 100,000 on Traffic Laws

Cadaveric Donors Per 100,000	OLS 4		OLS 5		OLS 6		OLS 7	
	β	SE	β	SE	β	SE	β	SE
Helmet (Full)	-1.22	(0.25)	-0.85[a]	(0.26)	-0.85[a]	(0.26)	-0.90[a]	(0.33)
Helmet (Partial)	-0.89	(0.24)	-0.64[a]	(0.24)	-0.62[b]	(0.24)	-0.66[b]	(0.32)
75 mph (rural)			0.23	(0.18)	0.23	(0.18)	0.24	(0.18)
70 mph (rural)			0.26[c]	(0.15)	0.23	(0.15)	0.30[c]	(0.16)
65 mph (rural)			0.28[b]	(0.11)	0.27[b]	(0.11)	0.27[b]	(0.11)
60 mph (rural)			1.15[a]	(0.27)	1.14[a]	(0.27)	1.18[a]	(0.28)
75 mph or greater (urban)			0.43	(0.33)	0.46	(0.33)	0.30	(0.35)
70 mph (urban)			0.35[a]	(0.11)	0.36[a]	(0.11)	0.26[b]	(0.11)
65 mph (urban)			-0.32[a]	(0.08)	-0.30[a]	(0.08)	-0.35[a]	(0.09)
60 mph (urban)			-0.44[a]	(0.16)	-0.40[b]	(0.17)	-0.50[a]	(0.17)
Secondary Seatbelt Laws					-0.05	(0.10)	-0.07	(0.10)
Primary Seatbelt Laws					0.03	(0.12)	-0.06	(0.12)
% White							1.67	(3.31)
% Black							-0.80	(3.46)
% Female							-0.13	(0.11)
Ages 0 to 19							3.29	(2.53)
Ages 20 to 34							0.45	(1.78)
Ages 35 to 54							1.96	(1.65)
Ages 55 to 74							-1.08	(2.75)
No. of observations	966		966		966		874	
R^2	0.77		0.77		0.78		0.78	
Incremental F	16.18		10.08		9.08		5.9	
State and Year Fixed Effects	Yes		Yes		Yes		Yes	
Second Stage Controls	Yes		Yes		Yes		Yes	

Notes: 1) Standard errors, found in parentheses, are estimated using the Huber/White/Sandwich estimator of variance. All observations are weighted by the state's population in the given year
2) The excluded speed limits are rural 55 mph and urban 55 mph or less.
3) The F-stat provides a statistics to test the validity of the instruments.
4) Level of Significance: [a] = 1%; [b] = 5%; [c] = 10%

Table 5: Instrumental Variables Estimation of Living Donations per 100,000

Living Donors Per 100,000	IV 1		IV 2		IV 3		IV 4	
	β	SE	β	SE	β	SE	β	SE
Cadaveric Donors Per 100,000	-0.59[a]	(0.17)	-0.24[a]	(0.09)	-0.26[a]	(0.09)	-0.22[a]	(0.09)
Prevalence ESRD (diabetic)*	-2e-3[a]	(7e-4)	-1e-3[c]	(6e-4)	-1e-3[b]	(6e-4)	-1e-3[a]	(6e-4)
Prevalence ESRD (non-diabetic)*	5e-3[a]	(7e-4)	4e-3[a]	(5e-4)	4e-3[a]	(5e-4)	5e-3[a]	(6e-4)
% White	-5.70	(5.31)	-5.97	(4.29)	-5.96	(4.33)	-4.85	(4.86)
% Black	26.1[a]	(8.23)	24.6[a]	(6.14)	24.7[a]	(6.20)	32.3[a]	(7.02)
% Hispanic	8.73	(6.27)	7.30	(5.10)	7.36	(5.13)	9.92[c]	(5.66)
% Female	2.79	(23.5)	-18.0	(18.7)	-17.07	(18.8)	-8.28	(19.7)
% Obese	0.45	(1.35)	0.69	(1.13)	0.68	(1.13)	0.64	(1.15)
Income Per Capita ($10,000)	0.01	(0.04)	0.01	(0.03)	0.01	(0.03)	0.00	(0.03)
Population (100,000)	-0.01[a]	(4e-4)	-0.01[a]	(3e-4)	-0.01[a]	(3e-4)	-0.02[a]	(3e-4)
Age: 0 – 19	-48.6[a]	(13.4)	-38.0[a]	(9.96)	-38.5[a]	(10.1)	-34.7[a]	(10.6)
Age: 20 – 34	-56.3[a]	(12.4)	-46.5[a]	(9.11)	-46.9[a]	(9.18)	-42.7[a]	(9.48)
Age: 35 – 54	-44.6[a]	(12.5)	-36.1[a]	(9.70)	-36.4[a]	(9.76)	-33.8[a]	(10.4)
Age: 55 – 74	-53.7[a]	(13.9)	-36.4[a]	(9.71)	-37.2[a]	(9.77)	-29.8[a]	(10.1)
% Private Insured	-1.56	(1.24)	-1.12	(1.02)	-1.14	(1.02)	-0.56	(1.04)
% Medicaid	-5.93[a]	(1.51)	-5.34[a]	(1.27)	-5.37[a]	(1.28)	-5.12[a]	(1.34)
% Medicare	1.49	(2.80)	-0.61	(2.15)	-0.52	(2.15)	-0.53	(2.11)
% Military	-5.16[c]	(2.31)	-3.72[b]	(1.92)	-3.78[b]	(1.92)	-3.27[c]	(1.98)
% Catholic	-5.76[a]	(1.53)	-3.92[a]	(1.06)	-4.00[a]	(1.07)	-4.72[a]	(1.36)
% Jewish	-30.0[a]	(8.83)	-23.2[a]	(6.50)	-23.5[a]	(6.57)	-12.2[b]	(6.29)
% Other Religion	-1.49	(1.21)	0.12	(0.80)	0.05	(0.80)	0.29	(0.89)
Centered R^2	0.79		0.86		0.86		0.86	0.87
No. Observations	966		966		966		966	874
Instruments								
- Helmet Laws	Yes		Yes		Yes		Yes	Yes
- Speed Limits	No		Yes		Yes		Yes	Yes
- Seat Belt Laws	No		No		Yes		Yes	Yes
- Injury Death Controls	No		No		No		No	Yes
State and Year Fixed Effects	Yes		Yes		Yes		Yes	Yes

Notes: 1) All estimation samples consist of 46 states from 1988 to 2008. The unit of observation is state*year.
2) Standard errors are estimated using the Huber/White/Sandwich estimator of variance.
3) Level of Significance: [a] = 1%; [b] = 5%; [c] = 10%
4) All observations are weighted by the state's population in the given year.
5) Observations are lost due to two missing years in the Mortality files and missing marital status data.
6) * signifies End-Stage Renal Disease prevalence per million by state population

Table 6: Disaggregating the Effect of Cadaveric Donations on Different Sub-Samples of Living Donations

Models: Marginal Effect of Cadaveric Donations per 100,000 people on Living Donations	Biological Donors	Non-Biological Donors	Anonymous Donors	Spouse + Friends Donors
Instruments: Helmet Laws and Speed Limits	-0.09 (0.06) R^2 = 0.84	-0.21[a] (0.05) R^2 = 0.82	-7e-3 (4e-3) R^2 = 0.46	-0.20[a] (0.04) R^2 = 0.81
Instruments: Helmet Laws, Speed Limits, and Seat Belt Laws	-0.09 (0.06) R^2 = 0.84	-0.21[a] (0.05) R^2 = 0.82	-8e-3[c] (4e-3) R^2 = 0.46	-0.20[a] (0.04) R^2 = 0.81
Controls: Include (% Obesity)^2 Instruments: Helmet Laws and Speed Limits	-0.05 (0.06) R^2 = 0.85	-0.19[a] (0.04) R^2 = 0.82	-3e-3 (4e-3) R^2 = 0.45	-0.18[a] (0.04) R^2 = 0.83
Controls: Include (% Obesity)^2 Instruments: Helmet Laws, Seat Belt Laws and Speed Limits	-0.05 (0.06) R^2 = 0.85	-0.19[a] (0.04) R^2 = 0.82	-3e-3 (4e-3) R^2 = 0.45	-0.18[a] (0.04) R^2 = 0.83
Instruments: Helmet Laws, Speed Limits, and Injury Death Demo.	-0.06 (0.06) R^2 = 0.86	-0.19[a] (0.05) R^2 = 0.83	-7e-3 (4e-3) R^2 = 0.46	-0.20[a] (0.04) R^2 = 0.81
Instruments: Helmet Laws, Speed Limits, Seat Belt Laws, and Injury Death Demo.	-0.06 (0.06) R^2 = 0.86	-0.19[a] (0.05) R^2 = 0.83	-8e-3[c] (4e-3) R^2 = 0.46	-0.21[a] (0.04) R^2 = 0.81

Notes:
1) All estimation samples consist of 46 states from 1988 to 2008. The unit of observation is state*year.
2) Standard errors, in parentheses, are estimated using the Huber/White/Sandwich estimator of variance.
3) Level of Significance: [a] = 1%; [b] = 5%; [c] = 10%
4) All observations are weighted by the state's population in the given year