Donor Compensation and the Elimination of the Organ Shortage in Spain: Evidence from Break Point Analysis

by

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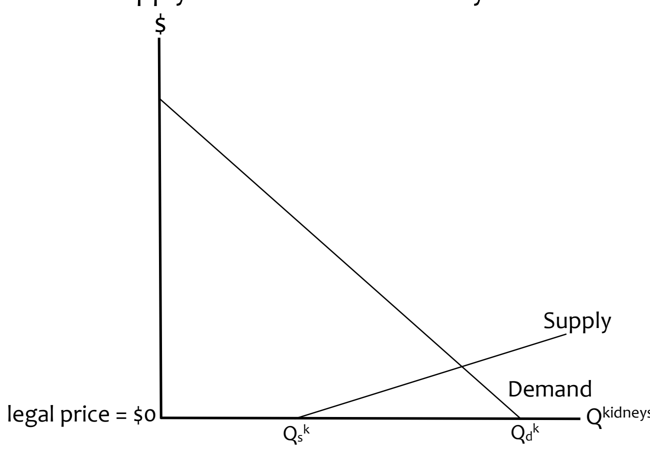
Abstract. The shortage of organs in most countries around the globe is, as explained by economists, a result of legislation outlawing the buying and selling of human organs. Spain, for example, has prohibited the commodification of organs since 1979, yet the Spanish system of organ procurement goes beyond that of most other countries by allowing organ procurement officials to offer monetary compensation, which is generally presented as funeral cost assistance, to the families of potential deceased donors. As a result, Spain's prior shortages have been eliminated, which means that Spain has stabilized and reduced the waiting list for kidney grafts. This study focuses on the lack of transparency inherent in the Spanish system of organ procurement, with the attendant likelihood that *sub rosa* payments perhaps extend beyond what is required to cover funeral costs. More specifically, we use a forecasting procedure – the Quandt-Andrews unknown break point test – to determine exactly when, after ONT revamped Spain's model of organ procurement in 1989, the kidney shortage in Spain was eliminated and the country's waiting list was stabilized (and began to fall). Our results indicate that Spain successfully addressed its previous kidney shortage by 1998, or about 10 years after implementation of the country's compensation-based procurement model. Additionally, a meta-type analysis, using survey-based evidence from prior research, suggests that Spanish procurement officials may have been, at the time the kidney shortage was eliminated, providing the families of deceased donors a financial reward in the neighborhood of €1287 (in today's currency).

Keywords: organ shortage in Spain; supply of kidneys; price ceiling; Quandt-Andrews unknown break point test
JEL Codes: D64, D72 and I18

1. Introduction and Background

According to data from the U.S. Department of Health and Human Services (HHS), the number of Americans on a waiting list for some type of organ transplant rose by more than a factor of five – from 23,198 to 121,272 – from 1991 to 2013.[1] Such an astounding stock shortage is, as explained by economists, a result of the price ceiling legislation known as the *National Organ Transplant Act of 1984* (hereafter *NOTA84*), which outlawed the buying and selling of internal organs in the U.S. (Carlstrom and Rollow, 1997). As one might expect, volumes of academic research on the policy failure related to the current organ shortage has been produced since the late 1980s. For example, a number of relatively recent books by economists, legal scholars, philosophers and others (e.g., Kaserman and Barnett, 2002; Taylor, 2005; Healy, 2006; Wilkinson, 2011; Beard, Kaserman and Osterkamp, 2013) delve into the social costs, ethics and morality considerations of the current environment surrounding organ procurement and allocation in the U.S. and elsewhere.

Figure 1. The Supply and Demand for Kidneys from Cadaveric Donors



The basic economic consideration of legislation such as *NOTA84* is presented in Figure 1. Depicted in Figure 1 are the supply and demand curves for a transplantable organ, such as kidneys.[2] As Kaserman and Barnett (2002: 18-19) indicate, the diagram in Figure 1 exhibits two empirical facts that are known with relative certainty about the market for kidneys. First, Q_s^k (i.e., the horizontal intercept of the supply curve), which represents the number of cadaveric kidneys that donors are willing to supply at the legal price of zero (i.e., $0), was, for the U.S. in 2014, a little more than 11,500.[3] Second, Q_d^k (i.e., the horizontal intercept of the demand curve), which represents the quantity demanded of cadaveric and living kidneys at the legal price of zero, was, for the U.S. in 2014, about 20,000 (Kaserman and Barnett, 2002).[4] In the U.S. in 2014, this figure is about 20,000 (Kaserman and Barnett, 2002). These numbers indicate that the annual shortage of kidneys in the U.S. is about 9,000.

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[1] See www.organdonor.gov/about/data.html for these and other related statistics on the organ shortage.
[2] The current presentation follows that in Kaserman and Barnett (2002: 18-19).
[3] See https://www.kidney.org/news/newsroom/factsheets/Organ-Donation-and-Transplantation-Stats.
[4] As in Kaserman and Barnett (2002: 18), this figure is found by adding the number of kidney donations (transplants) generated from cadaveric and living plus the number of wait-listed patients in 2014. See also https://www.kidney.org/news/newsroom/factsheets/Organ-Donation-and-Transplantation-Stats.

Many countries have experienced a legislative history governing the procurement and allocation of organs, along with the accompanying organ shortage, similar to that described above for the U.S.[5] In fact, the most recent of the scholarly books listed above (i.e., Beard et al., 2013) explains that Spanish law has prohibited payment for deceased-donor (and other source) organs since 1979. As such, Spain's prohibition of commodification of organs predates that in the U.S. by five years (Beard et al., 2013: 43). These authors also point out, however, that the Spanish system of organ procurement, which historically produced shortages, today goes beyond that in the U.S. in a number of important ways. Citing the work of Metasanz and Miranda (2002), Beard et al. (2013: 42-43) indicate that Spain's national transplant authority, the Organizacion Nacional de Transplantes (ONT), began a program in 1989 that has since expanded the supply of deceased-donor organs, especially kidneys, through the use of physician-led teams that are regularly apprised of the status of all potential donor patients in selected hospitals throughout the country. These "special coordination teams" are granted government funding to support their mission, which is further boosted by the use of compensation packages that tie financial rewards to organ procurement success.

Spanish organ procurement officials are also allowed to offer monetary compensation, which is generally presented as funeral cost assistance, to the families of deceased (potential) donors (Beard et al., 2013: 42-43).[6] The result has been a documented increase in deceased donors, from around 550 per year in the late 1980s to over 1,300 per year by the mid-2000s. Moreover, Spain's prior shortages have been eliminated, which means that Spain has stabilized, and reduced, the waiting list for kidney grafts (Beard et al., 2013: 25 and 42-43). Thus, as Beard et al. (2013) conclude, at a minimum the Spanish experience suggests that a good procurement system combined with relatively low dialysis populations (compared to U.S. levels) and available compensation can provide a solution to the kidney shortage in other parts of the world. There is, however, a caveat in this analysis given that the Spanish system of "financial assistance" is not transparent. Put differently, the existence of the financial awards (support) is not publicized, and procurement officials are able to use their judgment in the process (Beard et al., 2013: 181-182).

The lack of transparency inherent in the Spanish system of organ procurement, with the attendant likelihood that *sub rosa* payments perhaps extend beyond what is required to cover funeral and related costs, is the focus of the current study. To investigate this issue, we use a forecasting procedure – namely the Quandt-Andrews unknown break point test – on the Spanish time series of cadaveric kidney donations in order to determine exactly when, after ONT revamped Spain's model of organ procurement in 1989, the kidney shortage in Spain was eliminated and the country's waiting list was stabilized (and thereafter began to fall). The results from the Quandt-Andrews tests performed in this study indicate, depending on which time series of kidney donations is examined, that Spain successfully addressed its previous kidney shortage by about 1997-98, or just under 10 years after implementation of the country's compensation-based procurement model. Furthermore, a subsequent meta-type analysis, using survey-based evidence in Adams, Barnett and Kaserman (1999), provided in this study suggests that Spanish procurement officials may have been, at the time the kidney shortage was eliminated, providing the families of deceased donors a financial reward in the

[5] Most of these countries also face the economic situation described in the context of the U.S. by Figure 1.
[6] See Rodriguez-Arias, Wright and Paredes (2010) for a description of this process and the relevant Spanish legal authority.

neighborhood of €1287 (in today's currency). Before turning to the empirical tests described above, we first provide a brief look at survey-based evidence provided in Adams et al. (1999) concerning the supply of cadaveric organs in the U.S., given that is particularly applicable to our analysis of the supply of cadaveric kidneys and the elimination of the kidney shortage in Spain.

2. Kidney Donations in Spain: Data and Analysis

The conceptual model of the supply of organs in the U.S. presented by Adams et al. (1999), in conjunction with survey evidence also included therein, provides the foundation for empirical tests performed using Spanish organ donations series later in this study.[7] Survey evidence reported in Adams et al. (1999) suggests that compensation of U.S. donors in the amount of $1000 (for their organs) – or about $1400 in current dollars – would have been sufficient to increase the quantity supplied of organs in the U.S. during 1996 by about 117 percent above the quantity supplied at a zero price (i.e., the quantity donated), as represented as Q_s^k in Figure 1 above. As they indicate, this increase is more than enough to have eliminated the annual U.S. kidney shortage in 1996. Given that there are 25 transplantable parts of the human body, this compensation level comes to about $40 (or about $57 in current dollars) per cadaveric kidney donation (Adams et al., 1999).

Regression-based evidence (using the survey data) provided by Adams et al. (1999) also suggests the existence of a market equilibrium price (for organs) somewhere in the range from $135 to $1509, such as the midpoint of $822.[8] As Adams et al. (1999) point out, this midpoint is not only near the $1000 reported in their study, it is also close to the amount that Peters (1991) proposed as a financial incentive for organ donation in the U.S.[9] Had Peters' proposal, or the evidence provided by Adams et al. (1999), been used to formulate public policy in the U.S., 15,000 lives might have been saved (in the U.S.) between 1995 and 1999 (Adams et al., 1999: 154).

Given the lack of transparency in the Spanish system of cadaveric organ procurement, it is not possible to directly test the robustness of the findings from the survey-based research of Adams et al. (1999). We are, however, able to analyze the cadaveric kidney donations time series from Spain in order to draw some inferences about the efficacy of the organ supply study by Adams et al. (1999). An examination of these time series using economic forecasting techniques is conducted in the sub-section that follows.

2.1. The Supply of Cadaveric Kidneys in Spain: Quandt-Andrews Tests Results

The success of the OMP's efforts to eliminate the kidney shortage in Spain described in Beard et al. (2013) is easily seen in Figure 2, which presents the annual number of cadaveric kidney

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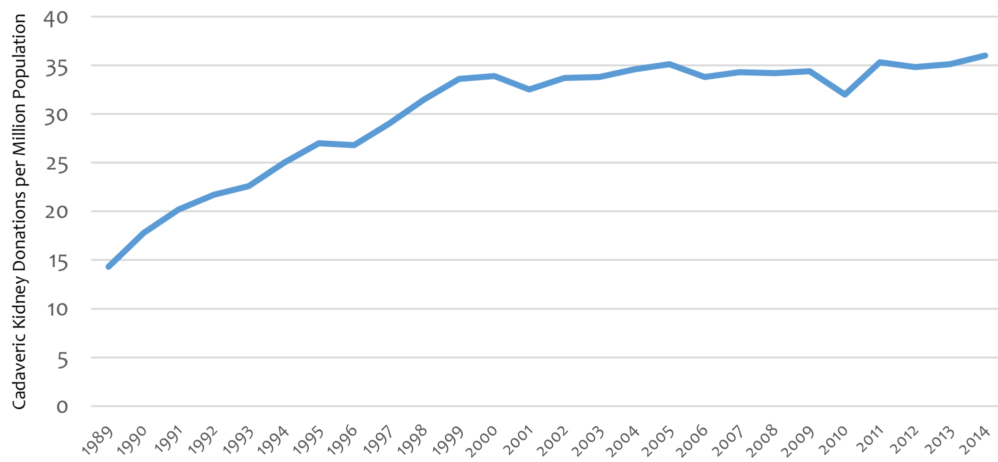
7 Adams et al. (1999) tackle two conceptual issues regarding the supply of organs – a potential negative intercept shift of the supply of organs (as in Figure 1 above) resulting from consumer distaste associated with "commodification" of the human body and the slope of the supply of organs – that are not addressed in this study. Survey evidence indicates that the former issue is relatively inconsequential and that the supply curve (of organs) is relatively flat. The latter point informed the configuration of the supply curve in Figure 1 of this study.
8 In 2014 dollars, this range runs from $192 to $2146, with a midpoint of $1169.
9 The current (i.e., 2014) value of the midpoint (i.e., $1169) is also near the $1400 reported here (see above).

donations per million population (pmp) in Spain from 1989 to 2014. This particular time series is characterized by a sharp increase beginning in 1989, the year during which the ONT began using special coordination teams whose members were compensated, at least in part, on the basis of procurement success in combination with a system of compensation to donors aimed at covering burial expenses. As depicted in Figure 2, kidney donations (pmp) in Spain appear to have levelled off prior to the turn of the twenty first century, and at a tier allowing the country to eliminate its previous shortage and begin to address the waiting list.

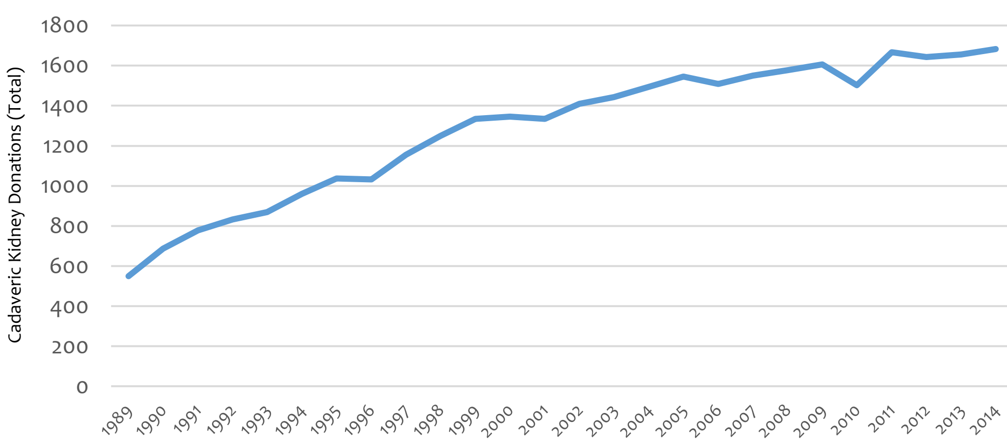
Figure 2. Cadaveric Kidney Donations (PMP) in Spain, 1989-2014



Source: Organizacion Nacional de Transplantes (ONT).

Figure 3 provides an alternative to Figure 2 by presenting the annual total number of cadaveric kidney donations in Spain from 1989 to 2014. This time series is generally increasing over the entire period under study, although the rate of increase appears to diminish just prior to the turn of the twenty first century. This element of the time series is consistent with the above portrayal of the donation rate series depicted in Figure 2. As such, this series also suggests that Spain perhaps eliminated its previous shortage and began to address the waiting list about 10 years after establishing (in 1989) its new program of organ (kidney) procurement commonly referred to as "the Spanish model."

Figure 3. Cadaveric Kidney Donations (Total) in Spain, 1989-2014



Source: Organizacion Nacional de Transplantes (ONT).

In order to better pinpoint how successful the Spanish model has been since 1989 this study employs a forecasting (statistical) procedure – the Quandt-Andrews unknown break point test. This procedure tests for one or more unknown structural breakpoints in the sample for a specified equation. The idea behind the Quandt-Andrews test is that a single Chow Breakpoint Test is performed at every observation between two dates, or observations, τ_1 and τ_2. The *k* test statistics from those Chow tests are then summarized into one test statistc for a test against the null hypothesis of no breakpoints between τ_1 and τ_2.[10] From each individual Chow Breakpoint Test two statistics are retained, the Likelihood Ratio *F*-statistic and the Wald *F*-statistic. The Likelihood Ratio (hereafter LR) *F*-statistic is based on the comparison of the restricted and unrestricted sums of squared residuals. The Wald *F*-statistic is computed from a standard Wald test of the restriction that the coefficients on the equation parameters are the same in all subsamples.[11] Our analysis focuses on the LR *F*-statistics.

The individual test statistics described above can be summarized into three different statistics – the Maximum (*Max*) statistic, the *Exp* statistic and the Average (*Ave*) statistic (see Andrews, 1993 and Andrews and Ploberger, 1994). The *Max* statistic, which is the maximum of the individual Chow *F*-statistics, takes the form:

$$MaxF = Max_{\tau_1 \le \tau \le \tau_2}(F(\tau)) . \qquad [1]$$

The *Exp* statistic, or the exponential *F*-statistic, takes the form:

$$ExpF = \ln\left(\frac{1}{k}\sum_{\tau=\tau_1}^{\tau_2}\exp(\frac{1}{2}F(\tau))\right). \qquad [2]$$

Lastly, the *Ave* statistic, which is the simple average of the individual *F*-statistics, takes the form:

$$AveF = \frac{1}{k}\sum_{\tau=\tau_1}^{\tau_2}F(\tau) . \qquad [3]$$

The distribution of these test statistics is non-standard. Although Andrews (1993) developed their true distribution, Hansen (1997) provided approximate asymptotic *p*-values.[12] The distribution of these statistics also becomes degenerate as τ_1 approaches the beginning of the equation sample, or as τ_2 approaches the end of the equation sample. To compensate for this behavior, it is generally suggested that the ends of the equation sample not be included in the testing procedure. A standard level for this “trimming” is 15 percent, wherein one excludes the first and last 7.5 percent of the observations. As pointed out above, these tests are applied to the two time series reported in Figure 2 and Figure 3.

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[10] By default, Quandt-Andrews tests whether there is a structural change in all of the original equation parameters.
[11] In linear equations these two statistics will be identical (Andrews, 1993; Andrews and Ploberger, 1994).
[12] These are generally reported by statistical software packages.

Table 1. Quandt-Andrews Tests Results

	Year	Test Statistics	*p*-value
Max LR *F*-statistic	1997	100.575	0.000
Exp LR *F*-statistic	1997	47.356	0.000
Ave LR *F*-statistic	1997	37.746	0.000

Note: Probabilities calculated using Hansen's (1997) method.

Table 1 presents the results from a Quandt-Andrews break point test (with 15 percent trimming) on the per million population donations series in Figure 2. Here, the null hypothesis (H_O) of no structural breaks within 19 possible dates was tested against the alternative (H_A) and rejected given statistically significant evidence of a structural break in 1997. Each of the three test statistics for the 1997 break point reported in Table 1 above is statistically significant at better than the 99 percent level of confidence. The robustness of this result is examined by applying the Quandt-Andrews break point test on the total donations series in Figure 3. These results are presented in Table 2, and indicate the existence of a structural break in 1998, thus generally supporting the previous finding. Again, each of the test statistics for the 1998 break point is statistically significant at better than the 99 percent level of confidence.

Table 2. Quandt-Andrews Tests Results

	Year	Test Statistics	*p*-value
Max LR *F*-statistic	1998	97.646	0.000
Exp LR *F*-statistic	1998	45.951	0.000
Ave LR *F*-statistic	1998	43.554	0.000

Note: Probabilities calculated using Hansen's (1997) method.

The results of the Quandt-Andrews tests presented in Table 2 are useful, in combination with the type of survey evidence reported in Adams, Barnett and Kaserman (1999) regarding the supply of organs in the U.S., in performing a meta-type estimation of the level of donor compensation that may have been required to eliminate the kidney shortage in Spain. This analysis is explained in the following sub-section.

2.2. The Supply of Cadaveric Kidneys in Spain: A Meta-Type Analysis

As we indicate at the beginning of this section of our study, survey evidence reported in Adams et al. (1999) suggests that compensation of donors in the amount of $1000 (for their organs) – about $1400 in current dollars – would have been sufficient to increase the quantity supplied of organs in the U.S. during 1996 by about 117 percent above the quantity supplied at a zero price – a percentage that is more than enough to have eliminated the U.S. shortage in 1996. Interestingly, between the implementation of the Spanish model (i.e., 1989) and 1998, the year identified by the second Quandt-Andrews break point test above and approximately the same year as the Adams et al. (1999) survey, the number of cadaveric kidney donations in Spain rose by 119 percent – an amount almost identical to that found in survey evidence regarding the U.S. shortage in Adams et al. (1999) from an increase in price from $0 to $1000 (or $1400 in current dollars). Thus, according to the evidence in Adams et al. (1999), Spanish procurement officials may have been compensating the families of deceased organ donors in the neighborhood of €1287.[13] Again, based on the potential procurement of 25 transplantable organs per donor, the previous total (i.e., €1287) comes to about €51 per cadaveric kidney. Moreover, a comparison with the regression-based estimation of market equilibrium price (for organs) reported in Adams et al. (1999) of $192 to $2146, with a midpoint of $1169 (all in current dollars) suggests an equilibrium price of cadaveric organs in Spain of €177 to €1974, with midpoint of €1075. This latter total is quite comparable to the €1287 reported above, and would yield a per-cadaveric kidney price of about €43.

3. Concluding Remarks

This study employs a forecasting procedure – the Quandt-Andrews unknown break point test – to determine exactly when, after Spanish organ procurement authors revised Spain's model of organ procurement in 1989 to allow for donor compensation, ostensibly to cover funeral costs, and piece-rate remuneration of procurement officials, the kidney shortage in Spain was eliminated and the country's waiting list was stabilized (and began to fall). Test results presented here indicate that Spain's cadaveric kidney shortage was perhaps eliminated in 1998, or about 10 years after implementation of is new procurement system, which is often referred to as "the Spanish model." This result is quite interesting, as it coincides with a point in time when Spain's annual kidney donations had increased by about 120 percent since 1989, which is increase in the quantity supplied of cadaveric kidneys of a magnitude that prior research on the U.S. kidney shortage suggests would be possible through the compensation of organ donors in the amount of $1400 (in 2014 dollars). If these figures are applied to Spain's experience from 1989 to 1998, then it is possible to conclude that Spanish procurement officials are compensating organ donors in Spain approximately €1287 (in 2014 currency).

[13] This amount is based on the aforementioned $1400 (current dollars) and a $1/€0.92 exchange rate.

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