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Risky Transportation Choices and the Value of a Statistical Life[†]

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This paper exploits an unusual transportation setting to generate some of the first revealed preference value of a statistical life (VSL) estimates from a low-income setting. We estimate the trade-offs individuals are willing to make between mortality risk and cost as they travel to and from the international airport in Sierra Leone. The setting and original dataset allow us to address some typical omitted variable concerns, and also to compare VSL estimates for travelers from different countries, all facing the same choice situation. The average VSL estimate for African travelers in the sample is US$577,000 compared to US$924,000 for non-Africans.
(*JEL* I12, J17, O15, O18, R41)

This paper exploits an unusual transportation setting to estimate the value of a statistical life (VSL). We estimate the trade-offs individuals choose to make between mortality risk and cost as they travel to and from the international airport in Sierra Leone, which is separated from the capital Freetown by a body of water. Travelers choose among multiple transport options, namely, ferry, helicopter, hovercraft, and water taxi. The setting and original dataset allow us to address some typical omitted variable concerns in order to generate some of the first revealed preference VSL estimates from a low-income country, filling an important gap in existing literature.[1]

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[1]Greenstone and Jack (2015) argue that "there is hardly a more important topic for future study than developing revealed preference measures of willingness to pay [for] … health" in developing countries. Revealed preference valuation approaches were first used in environmental economics (Hanneman 1980, 1983), but they are rarely employed in development economics.

Public policy decisions regarding investments in environment, health, and transportation often require estimates of a society's willingness to pay to reduce the mortality risks associated with alternative policies. These cost-benefit analyses reflect the dollar amount that should be spent on transport safety in order to save a certain number of lives (in expectation). For example, the California Department of Transport uses a VSL of US$2.7 million when assessing road safety investments.[2] Cost-benefit estimation of this sort is widespread in wealthy countries. However, the lack of credible VSL estimates in most low-income countries typically prevents the application of these methods for evaluating public projects, including, for instance, the large number of infrastructure projects that are currently being undertaken in Africa. The VSL estimates generated in our analysis can be used for a variety of public policy purposes, including informing debates within Sierra Leone regarding the desirability of constructing new transportation infrastructure, as well as applications in other African settings.

One well-known methodological challenge in obtaining reliable VSL estimates is the endogeneity of risks that individuals consider taking on (Ashenfelter 2006). The underlying individual factors that affect the decision to enter into a risky situation—where in the existing literature, risky job situations are often considered—may be correlated with many unobserved individual and job-specific characteristics, such as social status considerations and individual risk preferences, among others. To credibly estimate the VSL, we would ideally exploit exogenous events that affect the costs and/or the fatality risk individuals face, e.g., Ashenfelter and Greenstone's (2004b) use of legal changes to US highway speed limits, which leads them to estimate a VSL between US$1.0 and 1.5 million.

A strength of our study setting is the fact that all individuals who wish to travel to or from Sierra Leone by air need to choose among the available travel options to cross from the international airport to Freetown. This partially overcomes typical concerns about endogenous risk: while it is certainly possible that some foreign travelers are completely deterred by the risky transport situation, many others will be compelled to travel to Sierra Leone for professional or personal reasons. Moreover, all Sierra Leoneans seeking to fly abroad are inevitably faced with the airport transportation choice, substantially reducing the degree of selection into the sample as a function of individual risk attitudes.

We designed an original survey and administered it to 561 travelers to collect revealed preference data on current and past transport choices to and from the airport. This survey collected detailed information on a range of individual demographic, economic, and attitudinal characteristics, as well as on travelers' perceptions about the attributes associated with each of the different modes of transport, allowing us to control for many potential confounding factors.

Another notable aspect of the study setting is the relatively good information environment regarding transport risks in Sierra Leone. The rate of fatal accidents is high for several of the modes of transport we study, and accidents are widely publicized in the local (and international) media and the subject of frequent conversation

[2] See California Life Cycle Benefit Cost Analysis: Technical Supplement to User's guide available at http://www.dot.ca.gov/hq/tpp/offices/eab/benefit_files/tech_supp.pdf (accessed October 2015).

in the capital. The topic of how best to travel between Freetown and Lungi is commonly discussed among foreign travelers (as the authors can attest to first hand, since precisely such a conversation was the genesis of this paper). As we show below, there is relatively good knowledge among respondents about the relative risks of the different modes of transport, and a particularly high degree of awareness about the riskiness of helicopter transport, the mode with the greatest actual fatal accident risk.

It is also highly unusual to have individuals from so many countries all in the same dataset and facing the same choice situation, and this allows us to generate comparable estimates across nationalities. The average VSL estimate for non-African travelers in our sample, who are typically from OECD countries, is US$924,000. This is somewhat lower than most previous rich country estimates, which typically use hedonic approaches and range from US$1 million to US$9.2 million, but is similar to Ashenfelter and Greenstone (2004b).[3]

The only comparable estimates available from less developed countries (to our knowledge) are for manufacturing workers in India and Taiwan and range from US$0.5 million to US$1 million (Liu, Hammitt, and Liu 1997; Shanmugam 2001). These are in the same range as the estimates for the African travelers in our data, with an average VSL estimate of US$577,000 (PPP).[4] Kremer et al. (2011) use a travel cost approach—namely, willingness to walk longer distances to cleaner drinking water sources—to estimate the willingness to pay for avoiding a child diarrhea death among rural Kenyans, and find that it is very low in that setting, at under US$1,000.

Our estimates are based on the choices of middle-class and wealthy African travelers, and thus are complementary to Kremer et al.'s (2011) estimates derived from relatively poor rural households. Below we also discuss how VSL estimates from the middle-class and wealthy Africans in our sample of airport travelers are also of particular public policy importance. Given the scarcity of VSL estimates from low-income countries, generating estimates for even a nonrepresentative subset of the population is an important contribution (Greenstone and Jack 2015).

The fact that the estimated VSL for African travelers is somewhat lower than for non-African travelers (who are mainly from wealthy countries) is consistent with a growing body of research that documents the relatively low demand for health and life in less developed countries. The disease burden in low-income countries is much higher than in rich countries, and yet a number of scholars have documented surprisingly low investments in preventive health technologies (Kremer and Miguel 2007; Kremer et al. 2011; Cohen and Dupas 2010; Dupas and Miguel forthcoming). Common explanations (surveyed in Dupas 2011) range from a lack of information about new health technologies (Madajewicz et al. 2007), pervasive liquidity constraints (Tarozzi et al. 2014), time inconsistent preferences (DellaVigna and Malmendier 2006), agency problems within the household (Ashraf, Field, and Lee

[3] See, for example, Viscusi and Aldy (2003), Ashenfelter and Greenstone (2004b), and Lee and Taylor (2012). Ashenfelter and Greenstone (2004a) argue that estimates in this literature are subject to an upward publication bias.

[4] Previous studies in developing countries are based on compensating differentials in the labor market, which are often criticized for being particularly prone to selection bias. In the African context, Deaton, Forston, and Tortora (2010) use a subjective life evaluation approach to estimate the monetary value attached to the death of a relative.

2014), shorter life expectancy (Oster 2009), cultural attitudes (and especially fatalism, the belief that fate governs major life outcomes),[5] and a high income elasticity of demand for health expenditures (Hall and Jones 2007).

The dataset used in this study was specifically designed to assess the role played by several of these leading theoretical explanations, allowing us to make progress in understanding the underlying preferences that drive individual decision making regarding safety. We find evidence that individual earnings and fatalistic attitudes are both correlated with the VSL—namely, richer and less fatalistic individuals tend to have a higher willingness to pay for safety—and that average differences along these two dimensions between Africans and non-Africans in the sample can account for a portion of the gap in estimated VSLs. In the context of Africa's rapid current economic growth, it is useful to understand the role of both time varying factors, such as income, and relatively more fixed cultural attitudes (including fatalism) in determining the willingness to pay for safety. In contrast, individual perceptions of own life expectancy have far less predictive power.

The distribution of structural parameters in individual utility functions that we estimate in this study are potentially applicable to a range of other choice situations facing individuals, as well as policy choices in developing countries, for example, in the realms of public health, urban planning, transportation, and crime reduction. In the final section of the paper, we provide an illustration in a real-world policy context, putting our VSL estimates to work by evaluating the benefits of an infrastructure project that has recently been a matter of high-profile policy debate in Sierra Leone, namely, the construction of a new international airport. Under quite conservative assumptions, the VSL estimates in this paper imply that the increased safety benefits of the new airport alone may account for a substantial proportion of total projected construction costs.

I. Background on Sierra Leone

To reach Sierra Leone's Lungi International Airport from the capital of Freetown, travelers must cross an estuary that is roughly 16 kilometers (km) across at its widest point. There is no bridge and it is estimated that the best ground transport option around the estuary would take over six hours on unpaved and potentially dangerous roads, and we have no reports of travelers ever choosing that option (see map in Figure 1). All travelers arriving at Lungi Airport must choose between up to four distinct transportation alternatives (when all are operational)—ferry, helicopter, hovercraft, or water taxi—to cross the estuary. At the time of our survey, it was not possible to book tickets in advance, but rather they had to be purchased in person at the docking or landing site, or at the airport. All trips (for all the modes of transport) are precisely timed around the arrival or departure times of airline flights. We exploit the fact that transport options vary widely in terms of historical accident risk,

[5] Scholarly accounts highlight the ubiquity of fatalistic cultural attitudes in many African societies (Iliffe 1995, Gannon and Pillai 2010, Fortes 1984). In the extreme, fatalistic beliefs can lead to a lack of perceived individual agency and personal responsibility over many dimensions of life, e.g., see Bascom (1951).



Figure 1. Map of the Study Setting, Lungi International Airport and Freetown, Sierra Leone

Source: Created by authors using Google Maps

trip duration, and monetary cost. Importantly for our estimation, fatal transportation accidents are widely reported in the media and well-known to most travelers.[6]

Table 1 presents summary statistics on the available modes of transport, and travelers' perceptions of their attributes. The cheapest transport option is the ferry, at just US$2 per trip (or US$5 if you choose to travel in the so-called "VIP" section), though it is relatively slow, taking approximately 70 minutes to cross the estuary. On the Freetown side, the ferry terminal is located on the east side of the city at roughly the same distance from downtown (central) Freetown as the other modes' terminals, which are located on the west side (Figure 1). On the Lungi Airport side, the ferry

[6]The British High Commission advises (http://www.fco.gov.uk/): "Transport infrastructure is poor. None of the options for transferring between the international airport at Lungi and Freetown are risk-free. You should study the transfer options carefully before traveling." A Sierra Leone tourism site (http://www.visitsierraleone.org/) writes that: "Helicopters and Sierra Leone have a bit of a notorious past, with a couple of crashes widely reported"; and: "The cheapest option of all is to take the ferry to Freetown but it is certainly not the quickest option." The BBC reported the following: "A helicopter ferrying passengers to Freetown airport in Sierra Leone has crashed, killing 19 people, including Togo's Sports Minister Richard Attipoe" (BBC News 2007). Bloomberg News reported on a ferry accident: "105 people are feared to have drowned in Sierra Leone when a boat capsized." (Bloomberg News 2009). Local newspapers also regularly report on transport safety, including on a water taxi accident (along Sierra Leone's coast): "A passenger speed boat, Sea Master I, plying the Kissy Ferry Terminal/Tagrin route capsized at about 10:00 PM on Friday 27th February 2009 after making several distress calls to the pilot office of the Sierra Leone Ports Authority" (New Citizen Press 2009). There are (sadly) many other such examples.

Table 1—Transportation Options, Descriptive Statistics, and Accident Risk

	Mode of transportation				
	Ferry	Water taxi	Hovercraft	Helicopter	Road
Panel A. Average passenger traffic					
Number of trips per week	74	50	22	32	
Number of passengers per week (when operating)	4,440	1,100	1,826	640	
Percent of sample trips choosing this mode	56.7	25.3	16.0	2.0	—
Panel B. Costs					
Ticket cost in US$ (c_j)	0.5–2	35–40	35–50	70–80	N/A
Transit time in minutes (to/from Freetown dock/helipad)	70	35	28	12	240 +
Waiting time in minutes (avg.)	30	0	0	0	
Total travel time in minutes (t_j)	100	35	28	12	
Panel C. Accident risk (per 100,000 passenger-trips)					
Probability of fatal accident (p_j)	4.43	2.55	3.88	18.41	N/A
Probability of any accident	10.02	7.19	75.72	17.96	N/A
Panel D. Travel amenities (average, scale 1 to 5)					
Comfort of the seats	3.20	3.97	4.30	3.95	N/A
Less noisy	2.17	4.02	4.19	4.02	N/A
Less crowded	1.93	4.20	4.29	4.28	N/A
Convenient location	2.54	4.05	3.86	3.98	N/A
Quality of the clientele	3.32	4.30	4.38	4.39	N/A

Notes: Information on the monetary cost and travel time were obtained during fieldwork in August 2012. The probability of an accident is computed as the ratio of the total number of accidents observed during the reference period divided by the number of trips made by transport during the same period, taking into account the breaks in service for each mode of transport. Similarly, the probability of a fatal accident is computed as the ratio of the number of fatalities observed during the reference period, divided by the estimated number of passengers that made a trip during the same period. Information on choices was collected in the 2012 Sierra Leone Survey on Transportation Choices. To get information about the average time of the trip, the researchers did each trip from the airport to Freetown multiple times.

Sources: Information on fatal accidents was obtained by a comprehensive search of Sierra Leone and international newspapers during the period January 2005 through June 2012, the UN engineering department in Freetown, as well as several news sources.

landings are a greater distance from the airport (relative to the other modes), adding another 30 minutes in a bus, time that we factor into our analysis. The ferry has the second worst recent safety record. Since 2005, there have been three major fatal ferry accidents in Sierra Leone (including some on other routes), almost certainly due to pervasive passenger overcrowding. Accounting for the frequency of ferry trips, and the average number of passengers, this translates into a fatality risk of 4.43 per 100,000 passenger-trips.

The second major mode of transport is the water taxi, a small craft able to accommodate 12 to 18 passengers. Although there have been multiple reports of these boats sailing without proper lights or navigation systems, it appears empirically to be the safest option, with just one recorded accident since it started operating in December 2008, and an implied mortality risk of just 2.55 per 100,000 passenger-trips. The water taxi crosses the estuary in approximately 35 minutes and costs US$40.

The intermittently available hovercraft has an observed fatality risk of 3.88 per 100,000 passengers-trips (in five separate accidents, 2 of them fatal, with 17 passenger deaths overall). Its ticket price started at US$35 between December 2004 and

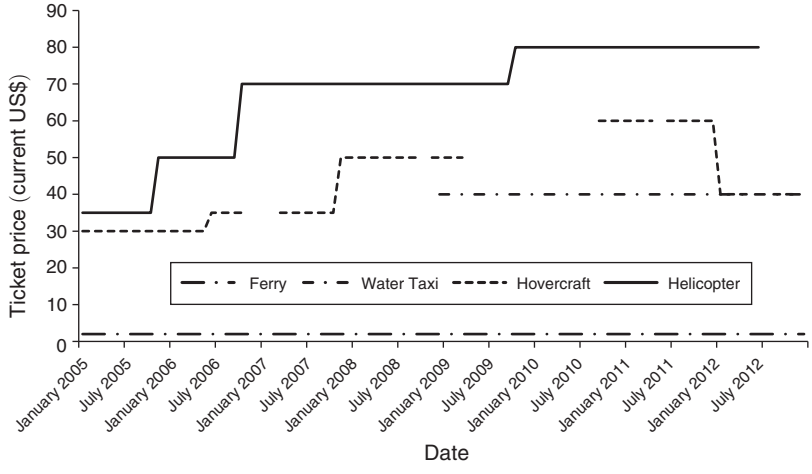


Figure 2. Operation and Pricing for the Modes of Transport

Notes: Data was collected by the authors through interviews with managers of the different modes of transport. The helicopter operated between March 2002 and June 2012. The water taxi has been operating since December 2008. The ferry has been operating continuously. The hovercraft started operations in December 2004, and has reported interruptions between: (i) October 2006 and February 2007, (ii) October 2008, (iii) between April 2009 and July 2010, (iv) May 2011; and (v) June and July 2012.

May 2006, then rose to US$50 until April 2006. After a period in which it was out of service (following an accident), it reopened in September 2010 charging US$60. In 2012 it reduced its price to US$40. In November 2012, the hovercraft stopped serving the public yet again.[7] The estimated travel time is about 28 minutes. In the analysis below, we consider the hovercraft as a possible alternative only during periods in which it was operating (Figure 2).

Finally, the helicopter is the most expensive option and also the fastest, at only 12 minutes to cross, yet has the worst accident record. The sole provider of the service used poorly maintained Soviet-era helicopters. Since 2005, there have been two helicopter crashes where all of the crew and passengers died (Table 2). Taking into account the frequency of trips as well as the number of passengers per trip, the historical fatality rate over 2005–2012 for helicopter transport is 18.41 per 100,000 passenger-trips, which is much higher than the 3 other modes and at least 30 times the fatal accident rate per 100,000 flying-hours in US helicopters.[8]

Our data collection effort includes retrospective reports from previous trips made by passengers. The fact that particular options were unavailable at certain periods of time is an advantage of our econometric identification strategy, as it provides largely exogenous within-individual variation in the choice set travelers face over time. In

[7] In our data, which includes retrospective reports on prior trips, we include all options available at the relevant time point. See Figure 2 for details on the dates in which each mode of transport was operating.

[8] US helicopter accident figures are from the 2009 Annual Report found at www.helicopterannual.org (accessed October 2015).

Table 2—Accidents on Freetown-Lungi Transportation Modes, January 2005–September 2012

Mode of transportation	Date	Deaths
Ferry	Mar. 12, 2006	120
	Aug. 2, 2007	158
	Sept. 9, 2009	120
Water taxi	Feb. 27, 2009	5
Hovercraft	May 5, 2006	6
	Aug. 18, 2006	11
	Nov. 13, 2007	0
	May 23, 2008	0
	May 19, 2011	0
Helicopter	June 3, 2007	19
	Oct. 18, 2007	22

Notes: Information on fatal accidents was obtained by a comprehensive search of Sierra Leone and international newspapers during the period January 2005 through September 2012, the UN engineering department database in Freetown, and interviews with the management of each of the modes of transport.

many cases, we observe the same passenger making transport choices at multiple points in time when facing different choice sets, providing more information about their preferences for money vis-à-vis risk. Online Appendix Figure A.1 shows the distribution of the historical trips present in our dataset. Forty-one percent of the trips took place in the trimester when our data was collected. Among the remaining 59 percent of trips, 23 percent took place in the first half of 2012 and the rest are spread out dating back to January 2005.

In our experience observing literally hundreds of trips (during surveying), there are typically few or no transport capacity constraints: in other words, if a given mode of transport is full at the scheduled time, there are more crafts available or additional trips can be made by the existing fleet (i.e., there are usually extra water taxis parked at each dock, the helicopter can make extra round trips, or more people are simply "squeezed" onto the ferry). Further, despite varying weather conditions, travel times in a given mode of transport are surprisingly constant.

Additionally, it is notable that the firms running the modes of transportation do not appear to be adjusting prices at high frequency or in a particularly sophisticated manner. Figure 2 shows the price charged on each of the modes of transport over time. The ferry did not change its price at all during the study period, mostly due to the government's influence in setting the price, nor do the private firms running the other modes appear to adjust their prices due to changing market conditions, i.e., variation in fuel costs, or changes in the competitive environment when the supply of other transport services changes, for instance, due to the frequent disruption of service for the helicopter and hovercraft (which might lead other operators to raise their prices, for instance). For example, the water taxi has charged US$40 since it started operating, and while the helicopter and hovercraft's prices have changed periodically, they do not seem to respond systematically to these other factors.

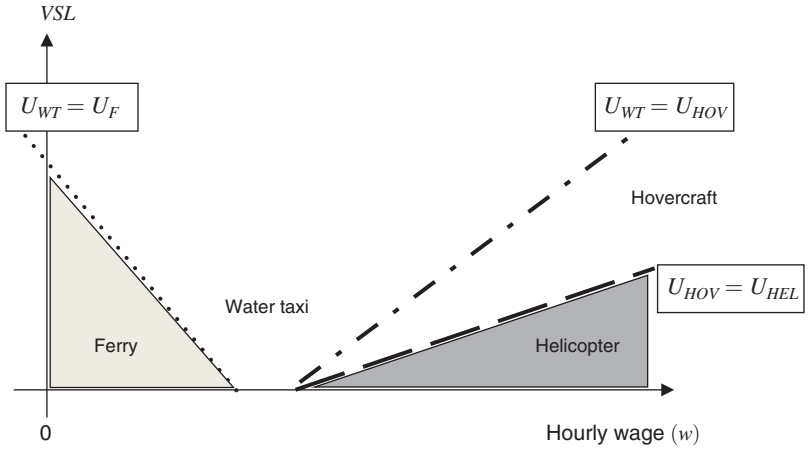


FIGURE 3. TRANSPORT CHOICE AS A FUNCTION OF WAGES (w) AND VALUE OF LIFE (VSL)

Notes: Each line represents the locus of VSL–Wage for which an individual is indifferent between two transportation options. The loci in the figure can be computed using the observed historical mortality risk, average historical transportation cost, and trip duration for each of the modes of transport. The transport names indicate regions of the parameter space where that mode is chosen, i.e., the shaded region in the bottom left of the figure (near the origin) is where the ferry would be preferred in expectation, etc. In the figure, the abbreviation "WT" denotes water taxi, "F" denotes the ferry, "HOV" denotes hovercraft, and "HEL" denotes the helicopter.

II. Estimating the Trade-off between Mortality Risk and Cost

In this section, we lay out a discrete choice travel cost model.[9] To convey the core intuition of the model, the basic trade-off between VSL versus the value of time (i.e., the wage) is first portrayed graphically in Figure 3 and then laid out formally below. Here we include three loci that correspond to iso-utility curves for the main transport modes.[10] The horizontal axis represents the passenger's hourly wage and the vertical axis plots the value of a statistical life (VSL). The relative risk and cost profiles of each alternative determine the intercepts and slopes.

The water taxi is the least risky option but lies between the ferry and hovercraft in terms of cost, as captured in both the ticket price and time (Figure 2). The fastest but riskiest option is the helicopter, which is also the most expensive. As shown graphically, individuals with high wages effectively choose between the helicopter and the hovercraft (since the very long travel time on the ferry generates high disutility). Those with sufficiently high value of life always choose the water taxi since it is safest, while those with lower valuations choose between the helicopter and hovercraft (if their wage is high) or pick the ferry (if their opportunity cost of time is low).

[9] The model laid out in this section is similar to the treatment in Greenstone, Ryan, and Yankovich (2012). That paper estimates the VSL for US military personnel choosing between job assignments that entail different mortality risk and wages.

[10] Note that the locus corresponding to equal utility for the ferry and helicopter is not shown since it lies in a region where both options are dominated by the water taxi.

The VSL represents how much additional cost an individual is willing to take on in order to (marginally) reduce mortality risk. This trade-off can be portrayed as

$$VSL_i \equiv \frac{\Delta M_i}{\Delta p_i}, \tag{1}$$

where ΔM_i is the change in individual i's income for a reduction of Δp_i in mortality risk.

We model traveler i's decision to use transport alternative j ($j \in J$, for discrete and finite J) to travel between Lungi Airport and Freetown using a random utility model of discrete choice:

$$y_{ij} = \begin{cases} 1 & \text{if alternative } j \text{ is chosen} \\ 0 & \text{otherwise} \end{cases},$$

where $\sum_j y_{ij} = 1$ and $\Pr(y_{ij}) > 0 \ \forall j$. Passenger i's utility from choosing mode j is

$$U_{ij} = (1 - p_j)v_i - (c_j + w_i t_j) + \varepsilon_{ij}, \quad \forall j, \tag{2}$$

where v_i represents the value to individual i from safely completing the trip, which happens with probability $(1 - p_j)$. c_j is the monetary cost of transport mode j. $w_i t_j$ is the opportunity cost, expressed in terms of the time it takes to complete the trip on $j(t_j)$ and the value of the individual's time (their wage w_i). It is useful to define total cost $c_{ij} \equiv c_j + w_i t_j$. ε_{ij} is an independently and identically distributed type I extreme value error term unobserved by the researcher. The distributional assumption on ε_{ij} implies that $\varepsilon^*_{ijk} = \varepsilon_{ij} - \varepsilon_{ik}$ follows the logistic distribution ($\forall\, j \neq k$).

Empirically, we estimate the VSL in a logit framework (McFadden 1974).[11] The probability of individual i selecting option $j \in J$ is given by the logit formula

$$\Pr(y_{ij} = 1) = \frac{\exp((1 - p_j)\, v_i - c_{ij})}{\sum_k \exp((1 - p_k)\, v_i - c_{ik})}. \tag{3}$$

From this expression, the relative odds of choosing mode j over k is

$$\begin{aligned} \frac{\Pr(y_{ij} = 1)}{\Pr(y_{ik} = 1)} &= \frac{\exp((1 - p_j)\, v_i - c_{ij})}{\exp((1 - p_k)\, v_i - c_{ik})} \\ &= \exp\big(v_i\big((1 - p_j) - (1 - p_k)\big) - (c_{ij} - c_{ik})\big). \end{aligned} \tag{4}$$

We normalize the utility of the outside option (of no travel) by setting it equal to zero. Building on the expression in equation (4), the relative utility of choosing

[11] For ease of exposition, we first present this conditional logit estimation framework before generalizing to the mixed logit framework, which is our preferred specification in the empirical analysis.

mode j is a function of the relative survival hazard of mode j vis-à-vis mode k ($[(1-p_j)-(1-p_k)]$, for $j \neq k$), and the relative cost of taking the different modes of transport $(c_{ij}-c_{ik})$:

$$U_{ijk} = \alpha + \beta_1\big((1-p_j)-(1-p_k)\big) + \beta_2(c_{ij}-c_{ik}) + \varepsilon_{ijk}. \tag{5}$$

Note that in this framework, the variation used to estimate the relevant coefficients comes from mode specific characteristics, and thus, any individual-specific variation that does not vary between modes (e.g., age, gender, etc.) is partialed out when taking differences between choices. Likewise, time-varying factors that do not vary between modes (e.g., weather conditions) are also not relevant in this estimation framework. (We generally ignore time subscripts in this discussion for parsimony.)

Totally differentiating equation (5), we obtain

$$\begin{aligned} dU_{ijk} = {} & \frac{\partial U_{ijk}}{\partial\big((1-p_j)-(1-p_k)\big)} d\big((1-p_j)-(1-p_k)\big) \\ & + \frac{\partial U_{ijk}}{\partial[c_{ij}-c_{ik}]} d(c_{ij}-c_{ik}). \end{aligned} \tag{6}$$

Setting $dU_{ijk} = 0$, and recognizing that the coefficients β_1 and β_2 capture the relevant partial derivatives on the key terms, this yields an expression for the value of statistical life that closely resembles equation (1):

$$-\frac{\beta_1}{\beta_2} = \frac{d(c_{ij}-c_{ik})}{d\big((1-p_j)-(1-p_k)\big)} \approx \frac{\Delta M_i}{\Delta p_i}. \tag{7}$$

β_1 represents the marginal change in the likelihood of choosing a certain transport mode due to a change in the probability of survival, and intuitively this corresponds to the utility value of completing a trip. β_2 captures how the likelihood of choosing a mode changes with cost, and corresponds to the monetary value of a unit of utility. The negative of the ratio of these coefficients captures the trade-off between exposure to fatal risk and cost, which can be interpreted as the value of a statistical life.

Standard conditional logit estimation of choice models, though simple to interpret and implement, have well-known limitations: they impose the assumption of the independence of irrelevant alternatives (IIA), and do not allow for random taste variation across individuals or for correlation in unobserved factors over time (Train 2003). We relax these assumptions by using a mixed logit model (McFadden and Train 2000). The IIA assumption is potentially problematic in our case since we have several trips made by the same individual under different choice sets, due to the intermittent operation of the hovercraft, the discontinuation of the helicopter service, and the introduction of the water taxi. The IIA assumption implies that the relative odds of choosing between two particular options remain constant when a new option is introduced. Further, conditional logit models assume that all agents in the population have the same preferences.

In contrast, the mixed logit model allows for random taste variation, enabling us to estimate individual-level coefficients and recover the full distribution of the VSL in the population. Mixed logit probabilities are the integrals of standard logit probabilities over a distribution of parameters. In this framework, we express the logit probabilities from equation (3) as

$$\Pr(y_{ij} = 1) = \int \left(\frac{\exp\left\{ \left[(1 - p_j) v_i - c_{ij} \right](\beta) \right\}}{\sum_k \exp\left\{ \left[(1 - p_k) v_i - c_{ik} \right](\beta) \right\}} \right) f(\beta)\, d\beta. \tag{8}$$

$f(\beta)$ is a density function and $\left[(1 - p_j) v_i - c_{ij} \right](\beta)$ is the observed portion of the utility, which depends on the parameter vector β. The mixed logit probability is a weighted average of the logit formula evaluated at different values of β, with the weights given by the mixing distribution $f(\beta)$. The assumptions on the mixing distribution used for each random coefficient can be derived from theory. For instance, it is theoretically plausible that β_1 is nonnegative for all passengers, if nobody prefers higher mortality risk on a given trip. Likewise, β_2 is plausibly less than or equal to zero, implying that, ceteris paribus, passengers prefer lower cost options.

Given the potential for reporting errors and our limited sample size, we sought to use a mixing distribution to minimize the possibility that outliers are driving our results. One distribution that fits these criteria is the restricted triangular distribution. This distribution is continuous and symmetric, and our assumptions on the respective signs of β_1 and β_2 allow us to anchor the support at zero. This distribution also implies that we only need to estimate a single parameter for each random variable, making estimation more tractable, and it is also attractive since it does not have the "thick tails" that characterize some other distributions (such the normal and log normal).[12,13]

III. Data

The Transportation Choice Survey was collected during August and September 2012 at both Lungi Airport and Freetown, among travelers either arriving into or departing from Sierra Leone. We verified that all three of the main transportation modes (ferry, hovercraft, and water taxi) were available on survey days; the helicopter was not operational during the months of the survey, but we did gather information on many past trips during periods when it was available. The surveys were collected at the landings for each mode of transport, either in Lungi or in Freetown. The data collection was timed with the arrival or departure of flights for which all modes of transport had a scheduled trip, and we interviewed one out of every four passengers at the landing. The average respondent took roughly nine minutes to

[12] Online Appendix Figure A.3 presents an example of a restricted triangular distribution. Kremer et al (2011) also use a restricted triangular mixing distribution in their analysis. Normal and log normal mixing distributions generate much less precisely estimated coefficients in our empirical application, with largely uninformative confidence intervals, and estimation often fails to converge; these are the leading reasons we focus on the restricted triangular results.

[13] Estimation of the mixed logit models was carried out using Matlab code developed by Kenneth Train; see http://eml.berkeley.edu/Software/abstracts/train1006mxlmsl.html (accessed June 2016).

complete the survey, and, remarkably, no passenger declined to be interviewed.[14] Enumerators recorded each respondent's observed transport choice, and the survey included self-reported transport choices on earlier trips, namely on their previous two trips across the estuary, and on their first two trips (if applicable), meaning that travelers could provide information on up to five trips.[15]

As noted above, an advantage of having historical trips in the analysis is that we are able to observe individual choices at times when different options were available, including the helicopter. In practice, this means that we have within-individual variation in the choice set, effectively allowing us to obtain information on both individuals' first and second choices in some cases, strengthening econometric identification. Further, the fact that we observe travelers from high- and low-income countries alike facing the same choice situation allows us to generate the first (to our knowledge) comparable revealed preference VSL estimates across nationalities.

Beyond the actual transportation choice, data was collected on respondents' demographic characteristics (including gender, age, nationality, permanent residence, and educational attainment), and current employment status and earnings.[16] Importantly, we ask respondents to rank their perceptions regarding the comfort, noise levels, crowdedness, convenience of the transfer location, and the overall "quality" of the clientele on each transport mode, allowing us to explicitly control for many attributes in the analysis. These are included as covariates in our main empirical specifications, and capture differences in choices due to perceived mode-specific amenities, which helps to address possible omitted variable bias.

We complement this survey data with information on all transportation accidents and associated fatalities between January 2005 and September 2012. This information was collected from the U.N.'s Engineering Department in Freetown, and cross-checked by the authors with multiple local and international newspapers. The list of accidents is presented in Table 2.[17] These reports include the number of fatalities for each accident. To compute the probability of an accident per passenger-trip, we also collected information on the number of trips per week by each mode of transport from historical records on all four modes of transport (throughout the country), as well as its passenger capacity.[18] The probability of dying in each of the modes is then computed as the ratio of the number of fatalities over the estimated number of passengers that used each mode during the study period (assuming that they operated at close to full capacity, which is roughly the case); these statistics are presented in Table 1, panel A.

[14] To provide incentives to complete the survey for passengers who were in a rush to get to the airport or home, each respondent received free cell phone air time worth about US$1 (enough for roughly ten minutes of calls).

[15] Our full sample is comprised of 1,793 trips made by 561 travelers (the average traveler reported 3.2 trips). 28.7 percent of respondents completed one trip, 17.8 percent two trips, 14.7 percent three, 20.6 percent four, and for 18.9 percent of respondents, we have data on five trips. Online Appendix Figure A.1 presents the timing of trips in our dataset between 2005 and 2012.

[16] About one-third of respondents have missing values for their earnings and wages. We impute missing observations with the average wage for other respondents with the same educational attainment category (namely, less than university, some/completed university, post-graduate), continent of residence (Africa or non-Africa), and employment sector (international organization/business, local organization/business, unemployed).

[17] There was an additional helicopter accident in 2001, during the tail end of the civil war, but we restrict attention to the period when the war was definitively over, as most comparable to our post-conflict study period.

[18] The information from historical trips and capacity is used to compute the fatality rates Table 1.

Table 3—Respondent Descriptive Statistics

	Africans ($N = 336$)		Non-Africans ($N = 225$)		Full sample ($N = 561$)	
	Mean	SD	Mean	SD	Mean	SD
Panel A. Transportation choices						
Transport taken: Ferry	0.67	0.47	0.36	0.48	0.57	0.50
Transport taken: Water Taxi	0.20	0.40	0.36	0.48	0.25	0.43
Transport taken: Hovercraft	0.11	0.32	0.25	0.43	0.16	0.37
Transport taken: Helicopter	0.02	0.13	0.03	0.16	0.02	0.14
Panel B. Respondent characteristics and attitudes						
Gender (1 = Male)	0.78	0.42	0.76	0.43	0.77	0.42
Age	39.87	10.91	41.17	11.97	40.34	11.30
Educational level: less than completed university	0.23	0.42	0.13	0.34	0.19	0.40
Educational level: complete university or more	0.77	0.42	0.87	0.34	0.81	0.40
Personally affected by civil conflict (Yes = 1)	0.58	0.49	0.15	0.36	0.43	0.50
Have children? (1 = Yes)	0.81	0.39	0.69	0.46	0.77	0.42
Knows how to swim?	0.36	0.48	0.74	0.44	0.50	0.50
Nationality: Sierra Leonean	0.58	0.50	0.00	0.00	0.37	0.48
Hourly wage (USD, PPP)—Measured	25.68	28.08	50.77	56.98	34.38	42.18
Hourly wage (USD, PPP)—Imputed	29.05	27.65	47.60	51.35	35.64	38.80
Self-reported belief of remaining life expectancy	42.75	11.89	39.77	12.26	41.69	12.10
Self-reported fatalism (scale 1 to 10)	4.21	3.05	3.27	2.57	3.87	2.92

Notes: "Africans" includes Sierra Leoneans. Panel A shows statistics for all trips recorded in the dataset (1,793 overall, 1,083 Africans, 710 Non-Africans). Panel B shows descriptive statistics at the individual traveler level (observations shown in the table header). All statistics are weighted to represent the observed proportions of the population taking each mode of transport. The PPP exchange rates come from the World Bank's World Development Indicators. The conversion to PPP uses the country of residence of the respondent. Wage imputations are based on three education categories (high school or less, some or completed university, and postgraduate), region of residence (African/non-African), and job status (government, international organization or private business outside Sierra Leone; local NGO, local business, academic/research/education; student/unemployed). 447 out of 561 respondents reported their wages (270 of 337 Africans, and 177 of 225 non-Africans.

Table 3 presents descriptive statistics for the 561 respondents with complete information on the relevant variables. Sixty percent of the total sample is African, from 20 distinct African countries, while the 225 non-African respondents come from 36 countries.[19] The travelers are mostly business travelers (38.4 percent), government officials or NGO workers (20.3 percent), or work for international organizations (33.6 percent), but we also have information for a few unemployed/students (5.3 percent), which provides wide variation in the background and income levels of our respondents.

Overall, including the historical trips, 57 percent of trips were made using the ferry, 25 percent on the water taxi, 16 percent using the hovercraft, and 2 percent with the helicopter. Airport travelers in our sample are an average of 40.3 years old and 77 percent are male (Table 3). They are highly educated—81 percent hold at least a university degree—and have relatively high incomes. Notably, the typical

[19] Fifty-four percent of the African respondents come from Sierra Leone, with the remainder mainly from Nigeria (38 percent of non-Sierra Leoneans), Ghana (20 percent), South Africa (17 percent), Kenya (4.1 percent), Senegal (3.9 percent), Liberia, Zambia, and Guinea (1.9 percent each), with smaller numbers from other countries. On the other hand, non-Africans in our sample come from the former colonizer United Kingdom (with 34.3 percent of non-Africans), United States (11.1 percent), India (9.4), France (5.3), China and Lebanon (3.7 percent each), Australia (2.6), Italy (1.9 percent), and the Netherlands and the Philippines (1.6 percent each), among others.

African respondent in our sample is clearly "elite" in local terms: she/he is both highly educated (77 percent hold a university degree) and has significantly higher income than the average African, with a reported hourly wage of US$29.90 (PPP), or $62,360 per year, which is higher than median US household income. Non-African respondents have an even higher average hourly wage of US$47.60 (US$99,000 per year).

The Africans in our sample are thus clearly not representative of the African or Sierra Leonean population, due to the sampling of highly selected airport travelers. While GDP per capita in Sierra Leone is just US$1,337 in PPP terms (World Bank 2014), the average Sierra Leonean traveler in our sample earns roughly 50 times as much, placing them near the top of the national income distribution. However, there is considerable socioeconomic dispersion in the data: a nontrivial share of our sample also have earnings more typical of urban African middle class households, with the median African respondent earning less than US$13 per hour, 12 percent of our African respondents earning less than US$8 per hour, and 12 percent of the Sierra Leoneans unemployed.

The VSL estimates for this relatively well-off African population are also especially relevant for certain public policy calculations, including regarding the benefits of building new airport construction, as we illustrate below, and other forms of public infrastructure (i.e., road safety measures) that will predominantly affect individuals who own or ride in automobiles. African elites like those in our sample may also have disproportionate political influence, and thus their preferences may be particularly important for public policymakers in general.

African respondents report that they expect to live for an additional 42.7 years (until 82 years of age), on average, while non-Africans' stated remaining life expectancy is almost identical, at just one year less. This may be surprising at first but seems consistent with the fact that the African elites captured in our sample are already about 40 years old (above the early childhood ages where most of Africa's high mortality occurs), and they likely have access to good health care. (Note that this data was collected roughly two years before the Ebola outbreak of 2014.) In terms of attitudes, the African travelers have much more fatalistic beliefs than the non-African travelers. When asked the extent to which they believe everything is determined by fate, versus believing they are able to influence their own future, they have an average fatalism score of 4.2 (out of 10), while non-Africans in the sample have an average of 3.3.[20]

Most travelers who chose the ferry claim to do so because of its lower cost (64 percent) and safety (84 percent) (Table A.1); note that ferry passengers are not significantly poorer or less educated on average. Travelers choosing the water taxi mention that their decision was based primarily on speed (85 percent) and safety (43 percent), while those choosing the hovercraft base it on safety (80 percent) and speed (73 percent). These patterns are broadly consistent with the intuition provided in Figure 3.

[20] Specifically, the question asked: "Some people feel they have completely free choice and control over their lives, while other people feel that what they have no real effect on what happens to them. Please use this scale where 1 means "no choice at all" and 10 means "a great deal of choice" to indicate how much freedom of choice and control you feel you have over the way your life turns out (code one number)." We reverse this original index so that 10 denotes "no choice at all" to create a measure of fatalism.

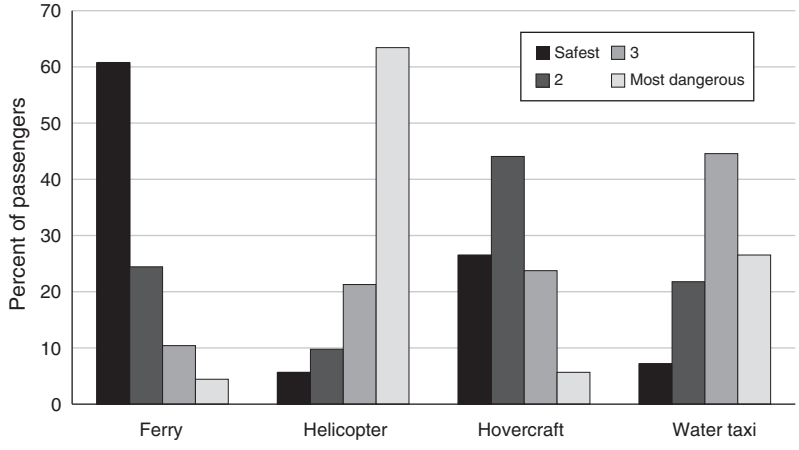


FIGURE 4. PERCEIVED TRANSPORTATION RISK RANKINGS

Notes: Each respondent was asked: "When traveling by road, air or water there are chances that an accident happens, and someone dies in the accident. Even though the chances that a fatal accident occurs are small, some modes of transport are safer than others. Moreover, these risks can change depending on the weather conditions (or the seasons). In terms of the chances of having a fatal accident on a day like today (in the rainy season, between May and September), that is, the chances that the mode of transport taken crashes, and a person like you dies in the crash: How would you rank the transport modes, from the safest to the most dangerous one?" The figure portrays the results from this question, weighted to represent the distribution of the traveling population. The same question was asked for the dry season, and the results are similar.

Source: Transportation Choice Survey 2012

Further, the extent of information that passengers have about the mortality risk of each of the modes of transport is shown in Figure 4. The questionnaire asked travelers to rank the transport options based on their relative risk of fatal accidents. Consistent with the actual fatality risk, the helicopter is perceived as the most dangerous option by 63 percent of travelers, while over 23 percent think that the hovercraft is the second most dangerous. The ferry is thought to be the second safest option by 24 percent of passengers, while 60 percent perceive it as the safest mode; this last case is one in which perceptions depart somewhat from observed accident risk. Finally, the water taxi's safety features are not clearly perceived by most travelers: 7 percent believe it is the safest option, but at the same time, 22 percent believe that it is the second safest mode. Overall, passengers' stated perceptions are moderately aligned with the observed accident risk across modes, suggesting that they are not completely in the dark when it comes to transport mode attributes.

While we recognize that findings from behavioral economics suggest that individuals often have difficulty making rational decisions when the odds of events occurring are very low, as with transport accident risk (Camerer and Kunreuther 1989; Barberis 2013; Kahneman and Tversky 1979; Kunreuther, Novemsky, and Kahneman 2001), we follow the existing literature and utilize a standard expected utility individual choice framework, using accident risk from historical data, in part due to the absence of a well-articulated and widely accepted alternative analytical approach that incorporates these behavioral concerns and generates meaningful valuation estimates.

IV. Main Results

A. *Value of Statistical Life Estimates*

Table 4 shows the main mixed logit model results. We regress the transportation choice indicator on the probability of successfully completing the trip (with estimates presented at × 1,000 for clarity of interpretation) and the total travel cost (in US$ PPP). Each observation represents an individual trip, and is weighted to represent the true proportion of passengers travelling on each of the available modes of transport; that is, we weight each observation by the inverse of its sampling probability.[21] We assume that the random coefficients associated with trip completion and costs both follow a restricted triangular distribution.

We find that passengers prefer transport modes with lower accident risk and lower cost (column 1). Following equation (7), we use the coefficient estimates on the safety and cost terms to estimate that the average value of a statistical life for African travelers is US$295,275 (PPP), and this is significantly different than 0. The analogous results for non-Africans indicate that they are more sensitive to changes in fatality risk and less responsive to cost (column 3), with an implied VSL for non-African travelers of US$1,010,737, which is statistically significant.

A leading concern with the estimates presented in columns 1 and 3—as well as in the broader VSL literature—is omitted variable bias. For example, the ferry is often quite crowded, while it is also quite safe and slow. On the other hand, while the helicopter is the riskiest option, it might also be perceived by some to be the most "high status" option. Not accounting for the correlation between the risk and cost terms and these other transport mode characteristics could bias the coefficient estimate on the safety term following the usual omitted variables logic. Similarly, many passengers (including the authors) dislike the loud rotor noise of the helicopter. Since the helicopter is also the most expensive and least safe option, there is thus a further correlation between the cost and risk terms with an amenity. Likewise, the more expensive options could also be most comfortable; this likely holds for the hovercraft (which has reasonably comfortable seats, although it can get hot on board due to a lack of ventilation) but probably not for the helicopter, and so on. The general point is that there is a need to account for travelers' perceptions of the various transport modes' multiple amenities.

To address this issue, we include individual-level perceptions on multiple attributes of each transport mode as covariates. Particularly, we asked every passenger to rank specific attributes on a scale from 1, "very poor," to 5,"excellent," (and then rescale them from 0 to 1 in the analysis). Among the amenities that we collected information on are some related to comfort (comfort of the seats, noise level), the convenience of the docking or landing location, and others related to its "status" (e.g., "quality of the clientele"), or potential dangers (e.g., crowded vessels may attract pickpockets). Individuals might not have direct experience with each of the

[21] The sampling probabilities for each transport mode are defined as: (Overall proportion of airport travelers using transport mode j)/(Proportion of survey respondents using transport mode j).

Table 4—Transportation Choices and the Value of a Statistical Life—Mixed logit Estimates

	Africans		Non-Africans		Full sample	
	(1)	(2)	(3)	(4)	(5)	(6)
Random coefficients						
Probability of completing the trip $(1 - p_j)$	7.809	10.209	10.936	10.572	8.559	10.155
	(1.769)	(2.182)	(2.205)	(2.311)	(1.371)	(1.595)
Total transportation cost $(Cost_{ij})$	−0.032	−0.020	−0.012	−0.012	−0.026	−0.019
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)
Fixed coefficients						
Ranking: Comfort of the seats		−0.483		1.205		0.109
		(0.347)		(0.416)		(0.263)
Ranking: Noise level		0.478		−0.232		0.137
		(0.394)		(0.415)		(0.284)
Ranking: Crowdedness		−1.162		−0.258		−0.694
		(0.353)		(0.401)		(0.262)
Ranking: Convenient location		−0.735		0.379		−0.142
		(0.308)		(0.338)		(0.227)
Ranking: Quality of the clientele		0.179		−0.593		−0.339
		(0.398)		(0.458)		(0.296)
Observations	3,292	3,292	2,124	2,124	5,416	5,416
Number of travelers	336	336	225	225	561	561
Number of trips	1,083	1,083	710	710	1,793	1,793
log-likelihood	−881.550	−855.262	−685.531	−679.567	−1,572.818	−1,556.953
Mean VSL (in '000 US$ PPP)	295.275	577.260	1,010.737	923.928	394.464	597.749
2.5 percentile	194.546	397.616	750.145	685.191	260.995	418.572
97.5 percentile	696.085	1,142.138	1,351.103	1,263.699	783.952	1,046.118

Notes: The data comes from a survey applied to travelers in August–September 2012. The probability of completing the trip is defined as one minus the probability of being in an accident and dying (× 1,000). Each observation is a unique traveler-transportation mode pair in the current choice. The dependent variable is an indicator equal to one if the traveler chose the transportation mode represented in the traveler-transportation mode pair. In every choice situation, we consider only the transportation modes available (i.e., the hovercraft is often unavailable), and limit the sample to trips that took place in January 2005 or later. All regressions are weighed to be representative to the share of travelers taking each individual mode of transport. The random coefficients associated with the probability of completing the trip and the total transportation cost are estimated using a restricted triangular distribution (where the trip completion term is assumed to be nonnegative and the cost term is assumed to be non-positive), while the other coefficients are assumed to be fixed. The VSL is the negative ratio of the coefficient estimates on the probability of completing the trip term over the total cost term, and its standard error is estimated using the delta method.

modes of transport, but their perceptions are still relevant if they influence choices.[22] Once we account for perceived transport mode characteristics (Table 4, columns 2 and 4), both coefficients of interest (on risk and cost) increase in magnitude compared to the specifications without these controls and this is particularly the case for Africans. The perceived amenities are jointly statistically significant in all specifications, justifying their inclusion. Accounting for the detailed transport covariates, our preferred estimated VSL rises to US$577,129 for Africans and decreases slightly to US$923,928 for non-Africans. Both confidence intervals exclude zero, but they

[22] A previous version of the paper used data collected in 2009 and 2010. These earlier surveys did not collect information on respondent's perceptions of the amenities of the transport modes. Given the relevance of the omitted variable bias issue in the VSL literature, here we employ the more comprehensive data collected in 2012.

Table 5—Value of a Statistical Life Estimates in Different Subsamples and with Alternative Specifications

			VSL (in '000 US$ PPP)		
				95 percent confidence interval	
Row	Estimation	Sample	Mean	Lower	Upper
(1)	Mixed logit	Full sample	597.749	418.572	1,046.118
(2)		Africans	577.260	397.616	1,142.138
(3)		Non-Africans	923.928	685.191	1,263.699
(4)		Sierra Leoneans	411.924	286.093	990.665
(5)		Africans, non-Sierra Leonean	856.559	526.720	1,281.698
(6)		Full sample, excluding first trip	490.930	368.584	794.655
(7)		Full sample, paid for the trip	521.349	366.147	1,003.541
(8)	Mixed logit, including weather	Full sample	793.055	541.402	1,406.617
(9)	controls interacted with risk	Africans	617.890	414.874	1,230.820
(10)	and cost variables	Non-Africans	1,579.203	942.776	2,379.649
(11)	Conditional logit	Full sample	984.261	198.428	1,770.095
(12)		Africans	778.492	235.181	1,321.803
(13)		Non-Africans	2,960.968	−4,674.640	10,596.57

Notes: The VSL estimates in each row come from a separate regression. Rows 1–7 are from mixed logit specifications like those in Table 4, and include controls for transport mode amenities. Rows 8–10 are from mixed logit specifications like those in Table 4, with additional interactions between weather controls (temperature, dew point, visibility, humidity, and wind speed) and the main variables (the risk variable and trip cost), including the interactions as fixed coefficients. Rows 11–13 are analogous to the specifications in rows 1–3 but using conditional logit specifications (estimation shown in columns 2, 4, and 6 in online Appendix Table A.3).

remain fairly large for both groups, presumably due to the limited sample size of a few hundred travelers in each group.

B. *Robustness Checks*

Table 5 presents VSL estimates for different subgroups and methods. Each row contains the estimated mean VSL and associated 95 percent confidence interval from a different specification, all of which include the transport mode amenity controls. The first three rows reproduce results shown in Table 4 for the full sample, Africans and non-Africans, respectively.

A key assumption of our model is that travelers are well informed about accident risk. Results from our survey indicate that travelers are aware of the broad ranking of safety (i.e., the helicopter is riskiest, the hovercraft is in the middle, but many think the ferry is relatively safer than it is, etc.). Another way to assess the role of information is to test whether the estimated VSL differs for those travelers who are likely to be objectively better informed about travel risks. As one approach, it is reasonable to assume that Sierra Leonean travelers are generally more knowledgeable about the relevant risks than foreigners: all of the accidents were widely reported in the local media and the issue was even commented upon by the president.[23] At the

[23] Local press widely reported on public reactions to these accidents. For example, President Koroma addressed the issue when receiving a Togolese delegation; see http://www.statehouse.gov.sl/index.php/investment-guide/498-president-koroma-receives-togolese-delegation (accessed October 2015).

same time, Sierra Leonean airport travelers are broadly similar to other African travelers in terms of education and earnings, suggesting that those factors are unlikely to be driving differences. If foreigners are less informed than locals about accident risk, this could be reflected in their choices, and thus in the estimated VSL.

The VSL estimates for Sierra Leoneans (row 4) and non-Sierra Leonean Africans (row 5) are similar, with estimates being somewhat higher for the non-Sierra Leoneans, but the difference is not statistically significant. Further the coefficient estimates on the probability of completing the trip and travel costs terms are also not significantly different between these two groups of travelers (online Appendix Table A.2). Along the same lines, first-time Lungi airport travelers could conceivably be less knowledgeable about the relevant risks than more seasoned travelers. When we carry out the analogous estimation excluding all reported trips by first-time Lungi travelers (row 6), the estimated VSL is slightly smaller, but is nearly the same, and the main patterns described above are unchanged. While not entirely definitive, taken together these two results do suggest that poor information about accident risks is not a key driver of the VSL results, addressing a key concern in much of the related VSL literature.

One potential concern is that business travelers are sometimes reimbursed for their travel expenses, and thus they do not factor in the cost of the trip when choosing their mode of transport. About 40 percent of the travelers in our sample report that someone else paid for or will pay for part of their trip. The estimated VSL for travelers who paid for their own trip out of pocket is nearly unchanged (row 7), suggesting this effect is not large empirically. This is not entirely surprising since most of the variation in the total trip cost is driven by differences in wages and thus the opportunity cost of travel time across individuals.[24]

One additional concern with our estimates is that weather conditions might affect travelers' willingness to pay to avoid risk. For example, travelers could perceive that traveling on a water-based mode is more dangerous during rainy or windy days. We address this concern in the estimates shown in rows 8–10, in which we run the mixed logit regression including additional interactions between various weather variables (e.g., wind speed, dew point, humidity, visibility) and the risk and cost variables (included as fixed coefficients). The results are similar to the ones in the baseline specification. Further, the estimated VSL for non-Africans increases somewhat and is very similar to the estimates in Ashenfelter and Greenstone (2004b).

Finally, for completeness, we also present the estimated VSLs using the conditional logit model, and these are reassuringly similar to mixed logit estimates for the full sample, Africans, and non-Africans (rows 11–13), although the conditional logit estimates are somewhat larger in magnitude and less precisely estimated. (The full results are shown in online Appendix Table A.3.)

Recall data can sometimes be biased by individual perceptions, which could themselves be correlated with unobserved individual characteristics, thus potentially

[24] Passengers who got reimbursed and those who did pay for their trip are not substantially different along a number of observable characteristics. Even though there are more foreigners who do not pay for their trip (43 percent of non-Africans versus 30 percent of Africans and 26 percent of Sierra Leoneans get reimbursed), passengers who get reimbursed do not have higher average wages than those who pay for themselves (not shown).

biasing estimates. This is a concern since some reported trips occurred all the way back to 2005. Table A.4 in the online Appendix presents the main specification but in successive columns limits the data to trips made after 2006 (i.e., excluding 2005), after 2007 (excluding 2005 and 2006), etc. The results show that, if anything, excluding earlier trips leads to slightly larger VSL estimates, although the changes in magnitude are not large.

A further related concern is that the salience of the accident risk for a particular mode of transport might be higher in the aftermath of an accident, and thus in column 7 we present results excluding all trips that took place in the month of an accident or within two months afterward. Once again, the VSL estimates are largely unaffected by the exclusion of these trips, providing further indication of the robustness of the main VSL results.[25]

C. *Heterogeneity in the VSL Estimates*

We are able to generate the full distribution of the VSL across individuals using random coefficients estimated in the mixed logit model (Table 4, column 6). Panel A of Figure 5 presents the distribution for the full sample of respondents, while in panel B we split the sample between Africans and non-Africans. There is clearly considerable overlap between the two distributions, but the non-African distribution lies to the right of the distribution for African travelers.

The mean estimate for non-Africans is roughly twice as large as that for Africans, with distributions that are clearly differentiated, and these differences merit further exploration. We thus next explore the underlying drivers of passenger choices regarding the trade-off between mortality risk and income. Three leading hypotheses in the literature could potentially account for the lower estimates among Africans. First, people with a shorter remaining life span might rationally invest less in marginal reductions in mortality risk (Oster 2009). Second, in the African context it has sometimes been argued (mainly by noneconomists) that there is considerable cultural "acceptance" of morbidity and mortality risk, which itself may be an expression of pervasive fatalism (Fortes 1984, Caldwell 2000, Meyer-Weitz 2005). Third, it has been hypothesized that expenditures in life-prolonging technologies are highly sensitive to income (Hall and Jones 2007, Jones 2016), and thus poorer individuals will have a far lower VSL. Here, we present evidence that casts some doubt on the first hypothesis (as well as several others), and provide suggestive evidence that income differences and fatalistic cultural attitudes both have some predictive power in the data.

The different choices made by Africans and non-Africans do not seem to arise from differential perceptions regarding the amenity value of the modes of transport, which are similar (Figure A.2, panel A). However, there are meaningful differences in the wages of the two groups, with non-Africans earning more (panel B). On the other hand, Africans and non-Africans expect to live for roughly the same number of additional years, with nearly identical distributions (panel C), suggesting that

[25] The VSL estimates are also similar when using accident risk instead of mortality risk (not shown).

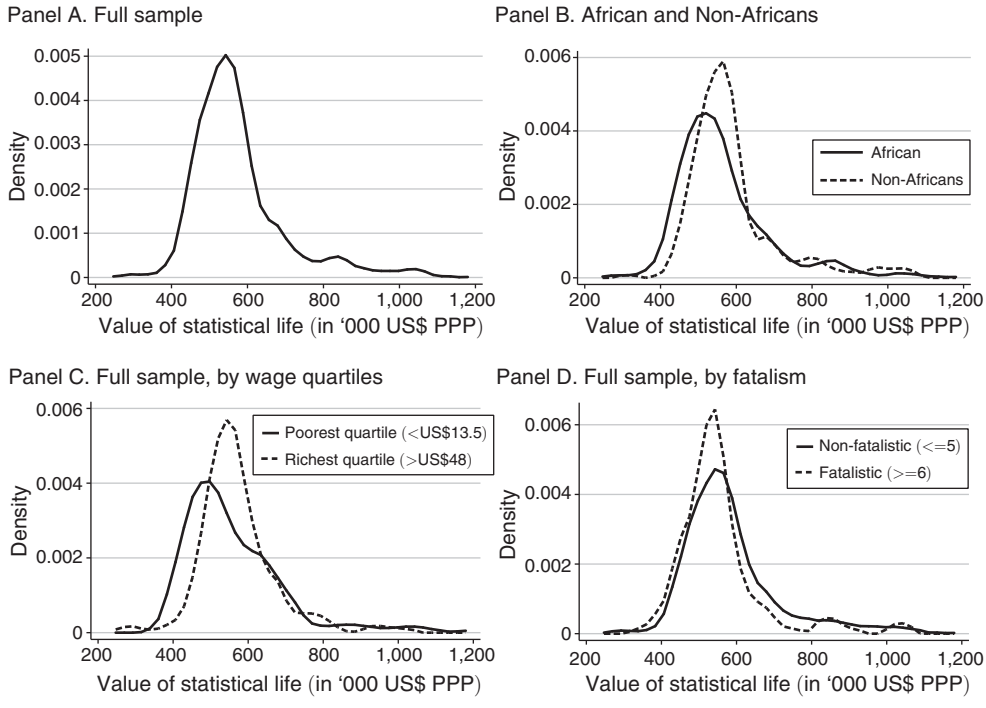


FIGURE 5. DISTRIBUTION OF INDIVIDUAL VSL ESTIMATES, MIXED LOGIT ESTIMATES WITH RESTRICTED TRIANGULAR DISTRIBUTIONS

Notes: Kernel density estimates of individual VSL estimates are from the mixed logit model in Table 4, column 6. The random coefficients associated with the probability of completing a trip and the costs of the trip are assumed to have a restricted triangular distribution. For presentation purposes, this figure trims the top 1 percent of the distribution. Panel B splits the sample for whether the respondent was born in an African country or not; panel C presents the VSL distributions for respondents in the lowest income quartile (daily wage $<$ US$13.50 PPP) and the top quartile (daily wage $>$ US$48 PPP); panel D presents the distributions for respondents who report having fatalistic attitudes (response to fatalism versus control question ≥ 6) and those who do not (response ≤ 5).

individual life expectancy is unlikely to be a key driver.[26] Finally, and consistent with previous evidence, Africans in our sample express significantly more fatalistic views than the non-Africans (panel D).

In Table 6, we examine the extent to which the above-mentioned variables can account for the variation in the VSL estimates, presenting OLS regression results that attempt to account for individual-level VSL estimates with individual observable characteristics related to the theories outlined above. The standard errors in these regressions are bootstrapped given the presence of a dependent variable that is itself estimated. The average difference between VSL estimates for Africans and non-Africans is statistically different at 99 percent confidence (column 1). We next progressively include remaining life expectancy, fatalistic attitudes, and log

[26] The question asked respondents whether they expected to be alive at a certain age, and for each affirmative answer we increased the age in five-year increments until the respondent answered in the negative.

Table 6—Determinants of the VSL across Individuals

	log(value of statistical life)					
	(1)	(2)	(3)	(4)	(5)	(6)
African (1 = yes)	−0.055	−0.052	−0.044		−0.041	−0.031
	(0.021)	(0.022)	(0.021)		(0.019)	(0.020)
Remaining life expectancy		−0.001				−0.001
		(0.001)				(0.001)
Fatalism (1–10 scale)			−0.011			−0.010
			(0.003)			(0.003)
log(hourly wage)				0.038	0.034	0.031
				(0.015)	(0.015)	(0.014)
Constant	6.377	6.434	6.410	6.218	6.256	6.323
	(0.017)	(0.053)	(0.023)	(0.048)	(0.046)	(0.055)
Observations (travelers)	530	530	530	530	530	530
R^2	0.01	0.02	0.03	0.02	0.03	0.05

Notes: The data comes from a survey applied to travelers in August–September 2012. The dependent variable is $\log(VSL_i)$ for each individual i as generated in the mixed logit model (in Table 4, column 6). Individuals without self-reported wages or earnings equal to zero are omitted from the analysis. In all OLS regressions, each observation is for a unique traveler. Bootstrapped standard errors with 1,000 random samples are in parentheses.

individual earnings (in columns 2–5), and then all three variables jointly in our preferred specification in column 6.[27]

Individuals who expect to live for longer in the future do not have significantly different VSLs (column 2). On the other hand, there is a negative and significant relationship between fatalistic attitudes and the VSL: individuals who believe that their destiny has been decided by a higher power are somewhat more likely to make risky transport choices and thus have a lower estimated VSL (column 3). This difference is also apparent visually (Figure 5, panel D). In columns 4 and 5, we estimate the income elasticity of the VSL by regressing the log(VSL) term on log(wages), and obtain an income elasticity that is positive and statistically significant, yet small. The estimate is less than one and on the lower end of estimates found in the literature.[28] This is consistent with the visible but relatively modest differences in the VSL observed between richer and poorer travelers in Figure 5, panel C.

When these three variables are jointly included in the analysis (column 6), the magnitude of the coefficient estimate on the Africa indicator variable drops substantially, by roughly 40 percent. Thus, differences in observed earnings and fatalistic cultural attitudes appear to account for a portion of the difference in VSL estimates between African and non-African travelers in our sample. However, they do not

[27] There are perhaps surprisingly weak associations between the individual VSL estimate and several individual characteristics including age, gender, having children, knowing how to swim (which might affect relative willingness to take sea versus air transport), and having been personally affected by armed conflict (not shown).

[28] There has recently been debate over the empirical income elasticity of the VSL, with estimates ranging between 0.4 and 1.7. For example, the contingent valuation studies reviewed in Viscusi and Adly (2003) typically estimate elasticities less than 1, ranging between 0.4 and 0.6. Many longitudinal studies estimate an elasticity greater than 1: Costa and Khan (2004) estimate an elasticity ranging between 1.5 and 1.7, and both Hall and Jones (2007) and Jones (2016) argue for an elasticity larger than one.

fully account for the difference in estimated VSLs between these groups, suggesting that further research to explain the gap would be useful.

V. Conclusion and Policy Application

This paper exploits an unusual transportation setting to provide revealed preference estimates of the value of statistical life (VSL) from a low-income economy. We generate novel revealed preference estimates by observing the trade-offs individuals make between mortality risk and travel costs among those traveling to and from the international airport in Sierra Leone among multiple transport options with different characteristics. The study setting allows us to partially overcome some typical problems faced in VSL estimation, particularly, the endogeneity of risk-taking and omitted variable bias. While differences between Africans and non-Africans are not always statistically significant, we find that the typical African traveler is somewhat less willing to pay for reduced mortality risk, with an average VSL of US$577,000 compared to US$924,000 for non-African travelers. We present suggestive evidence that this difference can be partly accounted for by differences in earnings and in fatalistic attitudes between the two groups.

The value of a statistical life is a key public policy parameter frequently used to evaluate the cost effectiveness of infrastructure projects that affect mortality risk. The VSL estimates in this paper are thus potentially of great interest in sub-Saharan Africa, which is currently one of the world's fastest growing regions and has experienced a boom in large-scale infrastructure projects in recent years (World Bank 2013). Until now, there have been few revealed preferences VSL estimates in Africa or other low-income regions. Further, most of the methods and best practices currently used to evaluate infrastructure projects base the computation of its benefits solely on their monetary profitability (see, for example, Dobbs et al. 2013), neglecting other economic and social benefits, such as safety improvements, and thus potentially generating misleading assessments of public policy attractiveness.

The VSL estimates we generate may be directly applicable in evaluating potential infrastructure projects within Sierra Leone itself. To illustrate, Sierra Leone President Ernest Bai Koroma met with China's president and vice-president to discuss three large infrastructure projects to be potentially financed with Chinese investment.[29] Importantly, one of the projects under discussion was the construction of an entirely new international airport, which would be located 40 km outside of Freetown and would allow travelers to drive to the capital by road and thus avoid the harrowing journey from Lungi that forms the backdrop for the current study. The initial estimated cost of the project is said to be approximately US$312 million. The project has been severely criticized in the media,[30] under claims that the economic benefits of the airport do not justify the cost, and rather, that money should be used for alternative development projects. Using this cost estimate, our

[29] Recent articles emphasize President Koroma's commitment to the project; see http://news.sl/drwebsite/publish/article_200523131.shtml (accessed October 2015).

[30] See, for example, http://www.thesierraleonetelegraph.com/?p=5120 (accessed October 2015).

own VSL estimates for African airport travelers, and making some conservative assumptions regarding the reduction in mortality risk generated by eliminating the Lungi-Freetown trip, we provide a back-of-the-envelope calculation regarding some of the project's other social benefits beyond any immediate boost in economic production.

We first assume that ground transportation will only be as safe as the safest existing transport mode, namely the water taxi, at 2.55 fatalities per 100,000 passenger trips; road travel is likely to be safer, but this is a conservative starting point. Given that the actual weighted mortality risk is 3.90 fatalities per 100,000 trips (taking appropriate averages in Table 4), this implies a reduction in mortality risk of approximately a third or 1.35 per 100,000 passenger trips.

Lungi International Airport's passenger traffic is currently roughly 14,000 passengers per week.[31] We assume that passenger traffic to the new airport (if and when constructed) will remain constant at this level, which means that the total yearly passenger traffic in the new airport would be approximately 700,000 passengers per year. This is again conservative given the rapid increase in total population and in business travel to Sierra Leone in recent years.

Using these two assumptions, the new airport would save approximately $1.35/100{,}000 \times 700{,}000$ passengers $= 9.45$ lives per year. Using the estimated VSL for African air travelers, this implies a social benefit of US$5.5 million per year. If the government or social planner discounts at 10 percent per year, the net present value of this benefit is approximately US$60 million. While this figure does not fully "pay for" the initial US$312 million cost estimate, it goes a long way toward justifying such an expense despite being driven by conservative assumptions on the reduction in accident risk and future air travel, and of course it does not account for all of the other intended benefits of a new airport in terms of international trade and economic growth.

This rough calculation is meant to illustrate how useful empirically grounded VSL estimates can be for public policy decisions in African and other low-income settings, as recently argued by Greenstone and Jack (2015). It is also worth noting that, given Africa's current rapid economic growth rates, our findings of a positive income elasticity of the VSL implies that value of life estimates may rise somewhat in the coming years, and this, too, is a trend that will be useful to factor into policy analyses in Africa and other low-income regions.

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[31] The approximate number of passengers per week was obtained for July 2013 by collecting data on all flights arriving and departing from the airport in a given week, assuming nearly full flights (95 percent of capacity), and accounting for the passenger capacity of each aircraft.

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