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Research Article

On the benefit transfer of the value of a statistical life

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Abstract

Objective: International and domestic benefit transfers of the Value of a Statistical Life (VSL) are conducted and the transfer errors are examined for Turkey. **Methods:** For the international transfers, (1) unit-value transfer with income adjustment, (2) the method developed by ECOTEC (2001) for EU candidate counties and (3) Value of a Statistical Life (VSL) derived for Turkey by recent literature are examined. For the domestic transfers, transfer errors are compared between unit-value transfer with income adjustment and function transfer methods. **Results:** While the lower-bound ECOTEC estimate results in the least transfer error, the unit-value transfer with income adjustment using the lower bound OECD value is also confirmed as "Very Good Fit" transfer if the income elasticity of VSL is 2.0-2.5 for the international benefit transfer. For the domestic transfer, unit-value transfer with income adjustment with base value = 740,838 TL (in 2012 TL) and the elasticity = 0.5 resulted in "Good Fit". When the transfer is necessary between the sites with different background risks, the function transfer with the basic demographic variables could improve the transfer results. **Conclusions:** We confirmed the applicability of benefit transfer practices for Turkey in both international and domestic context and identified the recommended methods of transfers together with the specific level of the income elasticities of VSL.

Keywords: Value of Statistical Life, benefit transfer, income elasticity of VSL, Turkey

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İstatistiksel yaşam değerinin fayda transferi

Öz

Amaç: Türkiye'de İstatistiksel Yaşam Değeri (İYD) için uluslararası ve ulusal fayda transferleri yapılmakta ve transfer hataları incelenmektedir. **Yöntem**: Uluslararası transferler için, (1) gelir ayarlamalı birim değer transferi, (2) AB aday ülkeleri için ECOTEC (2001) tarafından geliştirilen yöntem ve (3) Türkiye için yakın zamanda türetilen İYD incelenmektedir. Ulusal transferlerde, gelir ayarlamalı birim değer transferi ve fonksiyon transferi yöntemleri arasında transfer hataları karşılaştırılmaktadır. **Bulgular**: Uluslararası fayda transferi için alt sınır ECOTEC tahmini en az transfer hatasıyla sonuçlanırken, İYD'nin gelir esnekliği 2.0-2.5 aralığında olduğunda, alt sınır OECD değeri kullanılarak gelir ayarlamalı birim değer transferi de "Çok İyi Uyum" transferi olarak doğrulanmaktadır. Ulusal transfer ise, gelir ayarlamalı birim değer transferi baz değeri = 740.838 TL (2012 TL) ve esneklik = 0.5 ile "İyi Uyum" sağlanmaktadır. Farklı mevcut riskleri olan bölgeler arasında transfer gerektiğinde, temel demografik değişkenlerle fonksiyon aktarımı transfer sonuçlarını iyileştirebilmektedir. **Sonuç**: Türkiye için fayda transferi uygulamalarının hem uluslararası hem de ulusal bağlamda uygulanabilirliği doğrulanmış ve İYD'nin gelir esnekliklerinin belirli düzeyleri ile birlikte önerilen transfer yöntemleri belirlenmiştir.

Anahtar kelimeler: İstatistiksel Yaşam Değeri, fayda transferi, İYD'nin gelir esnekliği, Türkiye

Introduction

The Value of a Statistical Life (VSL) is derived statistically based on people's willingness to pay (WTP) for a certain mortality risk reduction. Individually, people consider (often unconsciously) the tradeoff between payments and risk reductions in the context of such services as preventive health checks, cancer screening tests, installation of child car seats, indoor air purifier, etc. Simply put, if a person agrees to take a cancer screening test which costs 500 TL out of pocket but could reduce mortality risk by 1 in 10,000 due to an early detection of cancer, VSL of the person could be calculated as at least 500/(1/10,000)=5,000,000 TL. Occasionally, we also evaluate the increased mortality risk from engaging in certain tasks in return for an increased income.

VSL is one of the most critical factors in the assessments of any policies and projects potentially influencing human mortality. VSL is not the value of human lives, but it is the statistically derived value based on the tradeoff between monetary wealth and the mortality risk made by everyone. VSL is widely used in the areas of healthcare, environment, transportation safety, food safety and the like around the world. For example, if the reduction of air pollutants to the EU standard level results in a mortality risk reduction by 1 in 10,000, how much are people willing to pay to support such a policy? If a change in environmental or health policy impacts the premature mortality of an affected population, the benefits of such policy changes must be clearly listed, not only as a mere item, but as the monetized value of the lives lost or saved. In general, while the monetary cost of policies intended to improve human health can be readily derived as accounting costs, the benefits are often difficult to clearly define, rarely monetized and hence underestimated in policy assessments. Hence, it is very important to identify the "correct" VSL estimates, especially when the VSL estimate based on the primary study is not available for a country or a specific region.

Benefit transfers have been often adapted to derive the necessary environmental or human health related values in monetary terms where the values based on primary studies are not available. Since there was no primary VSL estimate for Turkey prior to our study[1], Cost Benefit

Analysis (CBA) had to rely on the internationally transferred values. However, we could not know how accurately this reflected the true VSL for Turkey. Since we conducted a choice experiment to measure VSL for three areas in Turkey in 2012, it is now possible for us to numerically evaluate the transfer errors when we use the suggested method by OECD and EU.

VSL is used to monetize the benefits of health and environmental policies. Suppose that the average PM10 (particulate matter with the diameter less than 10μm) in Ankara is 64 μg/m^3 currently and in order to meet the EU air quality standard for PM10 (40 μg/m^3), the government needs to implement multiple projects to reduce the pollution level. Given the dose-response function derived for PM10[2], the premature mortality per 100,000 people is 6.72 per 10 μg/m^3 of PM10. In other words, if the government policy succeeds to reduce PM10 by 24 μg/m^3 (from 64 to 40 μg/m^3), this policy reduces 16.128 (= 6.72*2.4) persons' premature death per 100,000 people annually. Since the population in Ankara is 4,007,860 (2010 Census), a total of 646 premature deaths could be prevented as the result of this policy. In order to include this health benefit to CBA of this policy, we need to monetize this 646 lives-saved. Since VSL for Ankara was estimated as 689,104 TL (in 2012 TL)[1], 445,161,184 TL (= 646 * 689104) welfare gain could be realized just from PM10 reduction part of this air pollution reduction policy. According to studies conducted in the US, over 80 percent of monetized benefits from US air pollution policies are accounted through mortality risk reductions[3]. Hence it is critical to derive an appropriate VSL for a country and the policy sites to properly conduct CBA for the policies which influence human mortality. The primary aims of this study are twofold: (1) to conduct international benefit transfer (Between Country Transfers) to calculate the VSL for Turkey and judge the validity of using the methods suggested by OECD, EU and recent literature; and (2) to conduct domestic benefit transfer with unit transfers with income adjustments and function transfers using the estimated coefficients from our original choice experiment studies to investigate the possibilities of transfers to other areas in Turkey (Within Country Transfers). The second objective of this study is to provide a guideline for benefit transfer practices for VSL in Turkey. Under both international and domestic settings, our research is expected to contribute to better policy evaluations.

Methods

When we need to derive the country specific VSL, we either rely on primary research conducted for the country or conduct benefit transfer. There are mainly two approaches in benefit transfer. The first group is Unit Value Transfer, including: (a) simple unit transfer, (b) unit transfer with income adjustment, and the second group is Function Transfer with (c) benefit function transfer from one study and (d) meta-analysis[4]. While simple unit transfer is to transfer the VSL (or other estimated benefits) directly from study site (where the results from primary research are available) to the policy site (where researchers need VSL to do CBA, but VSL not available), the validity of the transfer should be carefully examined unless the characteristics of the study site and the policy site, as well as the environmental/health goods evaluated are very similar to each other. Hence an obvious extension of the method is (b) unit transfer with income adjustment. In this method, the value to be transferred is adjusted based on the mean income between the study and policy sites. In the following section, the methodology of (b) unit transfer with income adjustment (Section 2.1.) and (c) function transfer (Section 2.2.) will be discussed.

Unit Value Transfer with Income Adjustment Method

The basic idea of unit value transfer is to transfer VSL for a study site (where a primary VSL estimate exists), to a policy site (where primary VSL is not available). While the unit value transfer simply assigns VSLS (VSL at the study site) directly as VSLP (VSL at a policy site), the income adjustment is conducted by multiplying the income ratio with VSL for a study site as follows:

$$VSL_p = VSL_S \left(\frac{Y_p}{Y_S}\right)^{\beta}$$

where p and s stand for policy and study site, respectively, Y is the Purchasing Power Parity (PPP) -adjusted GDP per capita and β indicates the income elasticity of VSL. Purchasing Power Parity (PPP) is the rate of currency conversion to set the price of similar goods in different countries to be the same. It is quite different from the market exchange rate. For example, $1 = 1.02 TL if we use PPP while $1 = 1.796 TL by using the market exchange rate in 2012. In 2019, $1 = 1.841 TL for PPP and $1 = 5.674 TL for exchange rate (OECD data). Income Elasticity of VSL represents the relationship between income level and VSL. Since VSL is derived based on WTP for mortality risk reduction, it indirectly shows how changes in income level would change people's WTP for risk reduction. It measures the responsiveness of VSL to changes in income. Income elasticity of VSL = 0.5 means, 1% increase in income will result in an increase in VSL by 0.5%. Under general economic principles, the good evaluated is a "luxury good" if the estimated income elasticity of demand is greater than 1 and is a "necessity" if it is less than 1. Note that the income elasticity of VSL used here for between-country benefit transfer is different from the income elasticity of VSL we derive in Section 3.2.1 (within-country income elasticity of VSL).

Income Elasticity of VSL is a key component for unit-value transfer with income adjustment. It is often assumed to be between 0.8 [5] and 1 (for the benefit transfers to developing countries[6,7]), while Hammitt and Robinson (2011) suggest that the elasticity of VSL is likely to be greater than 1.0 for the transfers to the developing countries. There are currently a relatively small number of VSL studies available for developing countries-[7-11] and among the existing literature, the elasticity of VSL for developing countries are quite mixed. For example, Bhattacharya et al. (2007) report an elasticity of 0.55 for the case in India[9], and Hammitt and Zhou (2006)[12] find an even lower value in the range of 0.06 and 0.2 for mortality risk reduction in China. On the other hand, much higher income elasticities are reported in studies such as 2.44 for Iran[13], 1.7 - 2.3 for Chili[14] and 1.4 for China.[15] Tekeşin and Ara (2014) estimate the elasticity being approximately 0.5 for Turkey. Narain and Sall (2016) reports the list of existing VSL studies conducted in developing countries and compare the primary derived VSL with the VSL derived by using benefit transfers for 13 studies conducted in developing countries.[16]

Value Function Transfer Method

Function transfer method transfers the benefit function defined not only with income but also other determinants of WTP (e.g. characteristics of respondents, characteristics of environment, existing risk factors). If the data of the included variables in the benefit function are available for the policy site, this approach could be more appealing compared to the unit value transfers. Meta-analysis derives a benefit function including the determinants of WTP and the study characteristics using existing studies[17-21]. The limitations and the potential biases of meta-analysis are discussed in Navrud and Ready (2007)[4]. As is often the case, there is a tradeoff between the validity and the feasibility. Attempting to increase the validity of the transferred values leads to more complex forms of transfers which often require extra data and introduce further biases. As a result, it is possible to obtain higher transfer errors if we choose to use more complex functional forms with many variables.

The fundamental idea of value function transfer is that the average values of the policy site are plugged into the value function derived for the study site. Suppose the following value function was estimated for a study site, where PRICE corresponds to the presented WTP (bid) value, RISK is for mortality risk reduction and D1 and D2 are selected socio-demographic variables such as income and education levels.

$$V = \beta_0 + \beta_{PRICE} PRICE + (\beta_{RISK} + \beta_{D1} D1 + \beta_{D2} D2) RISK$$

Then VSL for the policy site can be derived by using all the estimated βs and the average values of D1 and D2 for the policy site as follows. The initial term is multiplied by 10,000 since in the original study, the

mortality risk reduction was evaluated as 1, 3, 5 or 8 in 10,000.

$$VSL = \left[\frac{-\frac{\partial V}{\partial RISK}}{\frac{\partial V}{\partial PRICE}}\right] * 10{,}000 = \left[\frac{-(\beta_{RISK} + \beta_{D1}\overline{D1} + \beta_{D3}\overline{D1})}{\beta_{PRICE}}\right] * 10{,}000$$

Methodology of VSL estimation for Turkey

Tekeşin and Ara (2014) conducted a choice experiment in 5 cities (Afşin, Elbisistan, Kütahya, Tavşanli and Ankara) in 3 areas (Afşin-Elbistan in Kahramanmaras province, Kütahya-Tanvşali in Kütahya province and Ankara) in Turkey in 2012 to estimate VSL for these areas. The population of each city was 84,244, 139,046, 101,001, 0.56 million and 4.9 million in Afşin, Elbistan, Kütahya, Tavşanli and Ankara, respectively. In other words, small, medium and large cities were respresented by Afşin-Elbistan, Kütahya-Tavşanli and Ankara, respectively. The choice experiment aims to reveal people's willingness to pay for mortality risk reduction. A face-to-face survey was conducted in each city, and a total of 1,248 valid responses were used to estimate VSL.

In the study, four attributes were used to determine the VSL, namely: PRICE (willingness to pay for the specific risk reduction), RISK (mortality risk reduction for one year), DATE (immediate risk reduction / the risk reduction starts one year from now) and RISK TYPE (mortality caused by lung cancer, other kind of cancer, respiratory disease, traffic accident). VSL was calculated by using the estimated coefficients (See various specifications and estimation procedures in Tekeşin and Ara (2014)) where the VSL estimates for each study area was obtained as 854,450 TL, 527,878 TL and 689,104 TL in 2012 TL, or 0.56, 0.35 and 0.46 million dollars in 2012 USD for Afşin-Elbistan, Kütahya-Tavşanli and Ankara, respectively. By using the pooled data, VSL of 740,585 TL or 0.49 million PPP-adjusted 2012 USD was found using the base model.

We found the income elasticity of VSL as 0.298, 0.626, 0.281 and 0.494 for Afşin-Elbistan, Kütahya-Tavşanli, Ankara and Pooled cases, respectively. While the estimates for VSL and the income elasticity of VSL were estimated with the NLOGIT program, Excel was used for the rest of the benefit transfer calculations based on the NLOGIT outputs.

Results

International Benefit Transfers

In this section, three between-country benefit transfer practices are applied to Turkey. The first approach is unit value transfer with income adjustment, the second is an approach developed to transfer values to EU candidate countries by ECOTEC and the last is the benefit transfer function derived by Milligan et al. (2014) and the latest VSL calculation suggested by Viscusi et al. (2017).

Unit Value Transfer with Income Adjustment with OECD Estimates

Unit value transfer with income adjustment is the most used benefit transfer approach.

OECD (2012) recommends a VSL range of $1.5 - 4.5 million (in 2005 USD), with a base value of $3.0 million (in 2005 USD) for OECD members and $1.8-5.4 million (in 2005 USD) with a base of $3.6 million for EU-27. Converting $3.0 million (the base VSL for OECD member countries) and $3.6 million (the base VSL for EU-27 members) in 2005 USD to PPP-adjusted 2012 USD, the base values become $ 3.55 million (OECD) and $ 4.22 million (EU-27) (PPP-adjusted, 2012 USD). In the calculation, 2012 GDP per capita in PPP-adjusted current (2016) international dollar is used for the calculation of the Yp/Ys ratio based on World Bank Database (http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD).

Using PPP-adjusted GDP per capita in current (2016) international dollars for OECD members ($37,517) and EU members ($35,241) as YS and $20,640 for Turkey as Y_P ($\left(\frac{Y_P}{Y_S}\right) = 0.55$ for OECD and $= 0.59$ for EU),

we can calculate VSLP with four different income elasticities (Table 1). According to this simple transfer method, the suggested VSL for Turkey using OECD base value ranges from $2.12 million (β = 0.9) to $2.39

million (β = 0.7) and they are $2.74 million (β = 0.9) to $3.05 million (β = 0.7) using EU-27 base value. When we adopt the lower bound values, the implied VSL for Turkey becomes between $ 1.06 million (β = 0.9) and $ 1.20 million (β = 0.7) using the OECD value and $1.37 million (β = 0.9) to $1.52 (β = 0.7) for the EU value.

By using our VSL estimate with pooled data of $0.49 million (PPP-adjusted 2012 USD), the transfer errors are calculated as shown in Table 1. Based on the transfer error categories reported in OECD (2011)[22], unit value transfer with income adjustment works well only if we use OECD based values with the high income elasticity of WTP (β =2.5). However, if we assume β = 1.0 as it is often assumed in studies, the transfer errors are unacceptably high. If we use the lower bound values for VSLS with OECD values, VSLP is derived with category 1 transfer errors (± 20%) for β being between 2.0 to 2.5, and for EU27 case, the transfer is reasonable if β is 2.5. Given these facts, it seems reasonable to use lower bound of OECD case with the income elasticity of WTP between 2.0 and 2.5 for the case of Turkey. It is also found that typically assumed β = 1.0 overestimates VSL for Turkey in the benefit transfer practice.

Table 1. Transferred VSL to Turkey from OECD/EU27 recommended VSL using unit transfer with income adjustment (in million PPP-adjusted 2012 USD).

		VSLp (PPP,2005$)	VSLp (PPP,2012$)	β = 0.7	β = 0.9	β = 1.0	β = 1.5	β = 2.0	β = 2.5
VSLs (OECD)	base value	2.9	3.64	2.39	2.12	2.00	1.48	1.10	0.82
	transfer errors			389%	334%	308%	203%	125%	67%
VSLs (EU27)	base value	3.5	4.41	3.05	2.74	2.60	2.00	1.54	1.18
	transfer errors			522%	460%	431%	308%	213%	141%
VSLs (OECD)	lower bound	1.5	1.82	1.20	1.06	1.00	0.74	**0.55**	**0.41**
	transfer errors			144%	117%	104%	51%	**12%**	**-17%**
VSLs (EU27)	lower bound	1.8	2.21	1.52	1.37	1.30	1.00	0.77	**0.59**
	transfer errors			211%	180%	166%	104%	57%	**20%**

Category 1 (±20) in bold.

ECOTEC Approach for EU Candidate Countries

Ecotech (2001) approach does not involve income elasticity of VSL and suggests the use of PPP weighting to adjust the base value for EU candidate countries[23]. It suggests the use of VSL for EU countries in the range of € 0.7 million to € 2.5 million with a central value of € 1 million for candidate countries. By using the PPP weighting (GDP per capita/PPP) for Turkey of 0.46, the VSL estimate for Turkey becomes € 0.46 million in 1999 Euros, it is inflated to € 0.613 million in 2012 Euros and $ 0.776 million in 2012 dollars. These values are calculated based on OECDdatabase (http://data.oecd.org/price/inflation-cpi.htm). The average Consumer Price Index (CPI) for EU-15 is calculated for 1999 and 2012, and the inflation is derived as 33.27%. The exchange rate between Euro and USD as of July 1st 2012 is used (1 Euro = 1.266 USD). If we use the lower bound of € 0.7 million, the derived value becomes $ 0.543 in 2012 USD (= € 0.7 million × 0.46 (weight) × 1.3327 (from 1999 to 2012 Euro) × 1.266 (from

Euro to USD)). In comparison with our VSL country specific estimate of 0.49 million PPP-adjusted 2012 dollars, the transfer error is 58% using the base value suggested by ECOTEC (2001), while the error is 10% using the lower bound of € 0.7 million. Therefore, we found that using the lower-bound of VSL reported in ECOTEC with the suggested weight of 0.46 predicts the true VSL for Turkey well. According to Table 1: Transfer errors in OECD (2011), transfer errors are classified as category 1 (Very good fit) if the transfer error is within ± 20, category 2 (Good fit) if the error is between ±20 and ± 50, category 3 (Poor fit) if the error is between ±50 and ±100 and category 4 (Very poor fit) if the transfer error is greater. In our case, the transfer can be categorized in category 1 (Very good fit).

Turkish VSL derived by Viscusi et al. (2017) and Milligan et al. (2014)

Viscusi et al. (2017) provides a list of VSL for close to 200 countries including Turkey[6]. They use a US VSL value ($9.631 million) as the base value, the income elasticity as 1.0 and each country's GNI (Gross National Income) per capita as the income of the policy site. According to their calculation, VSL for Turkey is calculated as $ 3.304 million (PPP-adjusted 2015 value). Since our estimate ($0.49 million PPP-adjusted 2012 USD) converted to PPP-adjusted 2015 value is $ 0.74 million, there is 4.5 times difference between these estimates.

Milligan et al. (2014) derived the transfer function for developing countries using meta-analysis

$$\text{VSL} = 1.3732\text{E} - 4 * (\text{GDP per capita})\text{^}2.478$$

where GDP per capital is in 2005 PPP-adjusted USD. Since 2012 GDP per capita for Turkey is $ 20,639.86 in 2016 PPP-adjusted USD, we can derive the suggested VSL using this transfer function with GDP per capital: $ 16,801.47 in 2005 PPP-adjusted USD as 4,056,399 (=1.3732E-4*(16801.47)^2.478). This estimate is even greater than the estimate from Viscusi et al. (2017). Hence, the transferred VSLs using the results of these recent studies may be overestimated.

Domestic Benefit Transfers in Turkey

In this section, within-country benefit transfers for Turkey are examined. In Section 3.2.1, we will examine the accuracy of unit value transfers with income adjustment using our primary data while Section 3.2.2 conducts benefit function transfer between these three study areas in order to identify the potential transfer errors to the cities where there are no VSL estimates. Section 3.2.3. reports the derived VSL estimates for other regions in Turkey using the benefit transfer with income adjustment. The income ratio using sample means of our data, as well as the median of household income for urban and rural areas obtained from 2011 Census (Turkish Statistical Institute (TÜİK) Population and Housing Census Data, 2011), are used to test the feasibility of transfers to other regions in Turkey. The result of this section could be incorporated into CBA and project/policy evaluation in other regions in Turkey.

Unit Value Transfer with Income Adjustment with Tekeşin and Ara (2014) Estimates

Unit value transfers are conducted among three study areas in Turkey. The mean monthly household income of our sample is 1,770, 1,825 and 2,796 TL for Afşin-Elbistan, Kütahya-Tavşanli and Ankara, respectively in 2012 TL. Based on the estimated VSL, income ratio between the study and policy sites, and the estimated income elasticity of WTP, we derive VSL for a policy site. We then compare it to the actually estimated VSL from our primary study for the policy site and calculate the transfer error as

$$e = \frac{VSL_{p\_BT} - VSL_{p}\_TRUTH}{VSL_{p}\_TRUTH} \times 100\%$$

where VSL_{P_BT} is the transferred value of VSL for the policy site using benefit transfer with income adjustment while VSL_{P_TRUTH} is the VSL estimate from the primary study (Table 2).

Except for the transfer from Afşin-Elbistan to Kütahya-Tavşanlı, the transfers are conducted successfully, and the transfer errors are within the range of Category 2: Good fit or better for most cases. The reason for the unsuccessful transfer between Afşin-Elbistan and Kütahya-Tavşanlı is based on

the relatively large difference between VSL estimates while their mean incomes are very close to each other. VSL for Afşin-Elbistan is significantly higher than the one in Kütahya-Tavşanlı mainly due to the higher background health risk in Afşin-Elbistan. The benefit transfer with income adjustment does not consider the differences of two separate locations in any other factors, including the difference in the background risks or health status. Therefore, if the socio-environmental-economic characteristics of study and policy sites are very different while their income levels are similar, it could result in the higher transfer errors.

In practice, we do not have any knowledge of VSL_{P_TRUTH} including the direction (smaller or greater than the base VSL). Based on the estimated transfer errors reported in Table 2, we recommend the use of Pooled VSL (= 740,838 TL) since the mean and the standard deviation of the transfer errors are the smallest (mean = 23.8%, standard deviation = 0.08) among other base VSLs. As for the income elasticity of VSL, we recommend the use of 0.5 for two reasons. First, the actual estimated elasticity of VSL using the primary data for Pooled case is 0.494, very close to 0.5. Second, when we compare the standard deviations of the transfer errors across different elasticities, we found that the standard deviation for the elasticity = 0.5 is one of the smallest comparatively. Hence, we recommend the use of the base VSL as 740,838 TL (in 2012 TL) and the income elasticity of VSL of 0.5 to transfer VSL to the policy sites in Turkey.

Table 2. Unit Value Transfer with income adjustment, within country transfers for Turkey

FROM	TO	Income	Income Elasticity	VSL_S	VSL_P (BT)	VSL_P (TRUTH)	Transfer Error
		Sample Average	0.1		857,039		62%
		= 1825/1770	0.3		862,300		63%
Elbistan	Kütahya		0.5	854,420	867,593	527,878	64%
			0.7		872,919		65%
			1		880,970		67%
		Sample Average	0.1		894,392		*30%*
		=2796/1770	0.3		980,033		*42%*
Elbistan	Ankara		0.5	854,420	1,073,874	689,104	56%
			0.7		1,176,701		71%
			1		1,349,694		96%
		Sample Average	0.1		550,885		**-20%**
		=2796/1825	0.3		599,951		**-13%**
Kütahya	Ankara		0.5	527,878	653,387	689,104	**-5%**
			0.7		711,582		**3%**
			1		808,737		**17%**
		Sample Average	0.1		526,265		*-38%*
		=1770/1825	0.3		523,054		*-39%*
Kütahya	Elbistan		0.5	527,878	519,862	854,420	*-39%*
			0.7		516,690		*-40%*
			1		511,969		*-40%*
		Sample Average	0.1		658,307		*-23%*
		=1770/2796	0.3		600,780		*-30%*
Ankara	Elbistan		0.5	689,104	548,281	854,420	*-36%*
			0.7		500,369		*-41%*
			1		436,235		*-49%*
		Sample Average	0.1		660,324		*25%*
		=1825/2796	0.3		606,321		**15%**
Ankara	Kütahya		0.5	689,104	556,734	527,878	**5%**
			0.7		511,202		**-3%**
			1		449,791		**-15%**
		Sample Average	0.1		727,248		**-15%**
		=1770/2130	0.3		700,812		**-18%**
Pooled	Elbistan		0.5	740,838	675,336	854,420	*-21%*
			0.7		650,787		*-24%*
			1		615,626		*-28%*

Table 2 continued

		Sample Average	0.1		729,477		*38%*
		=1825/2130	0.3		707,275		*34%*
Pooled	Kütahya		0.5	740,838	685,749	527,878	*30%*
			0.7		664,877		*26%*
			1		634,756		**20%**
		Sample Average	0.1		761,271		**10%**
		=2796/2130	0.3		803,842		**17%**
Pooled	Ankara		0.5	740,838	848,793	689,104	*23%*
			0.7		896,259		*30%*
			1		972,480		*41%*

1. VSL_S is VSL estimated from the survey for the study sites. 2. VSL_P is VSL derived using unit value transfer with income adjustments 3. VSL_{P_TRUTH} is VSL estimated from the survey for the policy sites. 4. Transfer errors are calculated as $(VSL_{P\_BT} - VSL_{P\_TRUTH})/VSL_{P\_TRUTH.}$ The bold indicates the error less than or equal to 20% (Category 1: Very Good Fit) and the italic shows the error less than or equal to 50% (Category 2: Good Fit) (OECD 2011).

Value Function Transfer Results

In this section, we use the following two models to conduct function transfers among three sites. The list of variable descriptions can be found in Table 3.

Table 3. Variable descriptions

Variable	Description
	Attribute variables
PRICE	200, 400, 600 or 800 TL
RISK	1,3,5 or 8/10,000 mortality risk reduction over 1 year
DATE	0 if risk reduction starts today, 1 if it starts one year from now
LUNG	1 if lung cancer, 0 otherwise
CANCER	1 if cancer except for lung cancer, 0 otherwise
TRAFFIC	1 if traffic accident, 0 otherwise
ASC_SQ	Alternative specific constant for status quo
	Individual Characteristics
HHINC	Monthly household income /1,000
GENDER	1 if the respondent is a female, 0 otherwise
AGE	Age of the respondent
UNIV	1 if having university or higher degree, 0 otherwise
OVER65	1 if the respondent is 65 and over, 0 otherwise
Variable	**Description**
ASTCB	1 if the respondent has experienced (experiencing) Asthma or Chronic Bronchitis in last three years, 0 otherwise
CVASC	1 if the respondent has experienced (experiencing) Cardio-Vascular disease in last three years, 0 otherwise
COAL	1 if coal is used as the main source of household heating, 0 otherwise
GDHLTH	1 if the respondent consider she is in good health, 0 otherwise

Model 1 includes the basic individual characteristics (Monthly Household Income, Age and Gender) together with the attribute variables from our choice experiment. The mean values for these characteristics for each policy area are publicly accessible from TÜİK.

$$V = \beta_0 + \beta_{PRICE} PRICE + (\beta_{RISK} + \beta_{HHINC} HHINC + \beta_{AGE} AGE + \beta_{AGE2} AGE^2 + \beta_{SEX} GENDER) RISK + \beta_1 DATE + \beta_2 LUNG + \beta_3 CANCER + \beta_4 TRAFFIC \quad (Model1)$$

Model 2 includes more detailed variables which are linked to health and environmental risks. Although UNIV and OVER65 variables are available from TÜİK, other variables are not readily available. Simple surveys may be necessary to access this data. Hence, although this model could potentially reflect the background risk factors and could theoretically derive more realistic benefit transfer practices, data requirements for the policy sites become greater.

$$V = \beta_0 + \beta_{PRICE} PRICE + (\beta_{RISK} + \beta_{UNIV} UNIV + \beta_{OVER65} OVER65 + \beta_{ASTCB} ASTCB + \beta_{CVSAC} CVASC + \beta_{COAL} COAL + \beta_{GDHLTH} GDHLTH) RISK + \beta_1 DATE + \beta_2 LUNG + \beta_3 CANCER + \beta_4 TRAFFIC \quad (Model2)$$

Given these two models, VSL can be calculated as

$$VSL = \left[\frac{-\frac{\partial V}{\partial RISK}}{\frac{\partial V}{\partial PRICE}}\right] * 10{,}000 = \left[\frac{-\left(\beta_{RISK} + \beta_{HHINC}\overline{HHINC} + \beta_{AGE}\overline{AGE} + \beta_{AGE2}\overline{AGE}^2 + \beta_{SEX}\overline{SEX}\right)}{\beta_{PRICE}}\right] * 10{,}000$$

for Model 1 and

$$VSL = \left[\frac{-\left(\beta_{RISK} + + \beta_{UNIV}\overline{UNIV} + \beta_{OVER65}\overline{OVER65} + \beta_{ASTCB}\overline{ASTCB} + \beta_{CVSAC}\overline{CVASC} + \beta_{COAL}\overline{COAL} + \beta_{GDHLTH}\overline{GDHLTH}\right)}{\beta_{PRICE}}\right] * 10{,}000$$

for Model 2, where $\overline{(Variable)}$ indicates the mean values of each variable for the policy site.

By using average values for each study area (Table 4), the VSL for policy sites are calculated as well as the transfer errors using the true estimated VSL.

The derived transfer errors using Model 1 and Model 2 are reported in Table 5 and 6, respectively. Transfer errors are very small for the transfers from Kütahya-Tavşanli to Afşin-Elbistan (|transfer error| = 1%) and from Ankara to Afşin-Elbistan (5%) using Model 1 and from Ankara to Kütahya-Tavşanli (7%) using Model 2. However, the other transfers are similar or worse than the errors derived under the benefit transfers with income adjustment. The transfers from the higher income to the lower income sites work better compared to the alternative. The result of Model 2 indicates that the inclusion of more detailed information does not necessary improve the performance of benefit transfers although for some cases, the function transfers perform better (i.e. Kütahya-Tavşanli => Afşin-Elbistan, Ankara => Afşin-Elbistan cases).

Table 4. Mean values for individual characteristics

Variables	Elbistan	Kütahya	Ankara
HHINC	1770	1825	2796
AGE	40.4	42.7	42.7
SEX	0.6	0.54	0.48
UNIV	0.12	0.11	0.32
OVER65	0.05	0.07	0.06
ASTCB	0.207	0.116	0.108
CVASC	0.11	0.11	0.09
HTCOAL	0.688	0.36	0.047
GDHLTH	0.385	0.48	0.473

Transfers from Study Areas to Other Areas in Turkey

We now conduct the benefit transfer using the unit value transfer with income adjustment using the regional average monthly household income (Table 7). As we recommended in Section 3.2.1, we use the base VSL as 740,838 TL with the income elasticity of VSL of 0.5. As reported in Table 8, the transferred values using the income elasticity of VSL as 0.5 ranges from 690,803TL (TR9 East Black Sea) to 867,411 (TR1 Istanbul) while for the elasticity set as 1.0, the value varies between 644,146 (TR9) and 1,015,609 (TR1). These values can be used in the evaluation of region-specific policies and projects which could potentially influence premature mortality.

Table 5. Function transfers using Model 1 (VSL in 2012 TL[3])

FROM (Study Site)	TO (Policy Site)	β_{PRICE}[1]	β_{RISK}	β_{HHINC}	β_{AGE}	β_{AGE2}	β_{SEX}	VSL_P	VSL_{P_TRUTH}[2]	Transfer Error
Elbistan	Kütahya	-0.006	0.325	0.101	0.009	-0.0002	-0.047	843,109	527,878	60%
Elbistan	Ankara	-0.006	0.325	0.101	0.009	-0.0002	-0.047	1,000,412	689,104	45%
Kütahya	Ankara	-0.010	-2.837	0.646	0.151	-0.002	-0.288	1,475,633	689,104	114%
Kütahya	Elbistan	-0.010	-2.837	0.646	0.151	-0.002	-0.288	842,608	854,420	-1%
Ankara	Elbistan	-0.006	-0.367	0.086	0.040	-0.0006	-0.034	812,380	854,420	-5%
Ankara	Kütahya	-0.006	-0.367	0.086	0.040	-0.001	-0.034	799,861	527,878	52%

[1.] βs are parameter estimates of study sites.[2.] Estimated using Choice Experiment. [3.] 1 USD = 1.8 TL (July 1st 2012).

Table 6. Function transfers using Model 2 (VSL in 2012 TL)

FROM (Study Site)	TO (Policy Site)	β_{PRICE}	β_{RISK}	β_{UNIV}	β_{OVER65}	β_{ASTCB}	β_{CVASC}	β_{COAL}	β_{GDHLTH}	VSL_P	VSL_{P_TRUTH}	Transfer Error
ELB*	KÜT	-0.007	0.841	0.67	-0.39	0.17	0.34	-0.40	-0.40	934,459	527,878	77%
ELB	ANK	-0.007	0.841	0.67	-0.39	0.17	0.34	-0.40	-0.40	1,334,938	689,104	94%
KÜT	ANK	-0.011	1.045	1.20	-2.68	0.54	0.34	-0.72	-0.06	1,194,182	689,104	73%
KÜT	ELB	-0.011	1.045	1.20	-2.68	0.54	0.34	-0.72	-0.06	633,403	854,420	-26%
ANK	ELB	-0.006	0.503	0.33	-0.10	0.38	0.02	-0.39	-0.31	388,530	854,420	-55%
ANK	KÜT	-0.006	0.503	0.33	-0.10	0.38	0.02	-0.39	-0.31	488,350	527,878	-7%

*ELB = Elbistan, KÜT = Kütahya, ANK = Ankara.

Table 7. Average monthly household income for statistical regions

	Mean monthly household income
Elbistan	1,770
Kütahya	1,825
Ankara	2,796
TURKEY	2,215
TR1 Istanbul	2,920
TR2 West Marmara	1,911
TR3 Aegean	2,312
TR4 East Marmara	2,280
TR5 West Anatolia	2,498
TR6 Mediterranean	1,945
TR7 Central Anatolia	2,041
TR8 West Black Sea	1,905
TR9 East Black Sea	1,852
TRA North East Anatolia	1,688
TRB Central East Anatolia	1,661
TRC South East Anatolia	1,446

Table 8. Unit Value Transfer to other regions in Turkey

FROM	TO	Mean Income (STUDY) Mean Income (POLICY)	Income Elasticity	VSL_S	VSL_P
POOLED	TURKEY	2,130 2,215	0.5 1	740,838	755,475 770,402
	TR1: Istanbul	2,130 2,920	0.5 1	740,838	867,411 1,015,609
	TR2: West Marmara	2,130 1,911	0.5 1	740,838	701,720 664,667
	TR3: Aegean	2,130 2,312	0.5 1	740,838	771,840 804,140
	TR4: East Marmara	2,130 2,280	0.5 1	740,838	766,480 793,010
	TR5: West Anatolia	2,130 2,498	0.5 1	740,838	802,287 868,833
	TR6: Mediterranean	2,130 1,945	0.5 1	740,838	707,935 676,493
	TR7: Central Anatolia	2,130 2,041	0.5 1	740,838	725,195 709,883
	TR8: West Black Sea	2,130 1,905	0.5 1	740,838	700,617 662,580
	TR9: East Black Sea	2,130 1,852	0.5 1	740,838	690,803 644,146
	TRA: North East Anatolia	2,130 1,688	0.5 1	740,838	659,507 587,105
	TRB: Central East Anatolia	2,130 1,661	0.5 1	740,838	654,212 577,715
	TRC: South East Anatolia	2,130 1,446	0.5 1	740,838	610,404 502,935

Discussion

In this study, we conducted benefit transfers both in international and domestic settings. For the international benefit transfers, we compared three approaches, (1) unit value transfer with income adjustment, (2) the method suggested by ECOTEC and (3) the derived results of recent international benefit transfer studies for Turkey. Our findings indicate that for international benefit transfer with income adjustment, we need to use the income elasticity of WTP between 2.0 – 2.5 together with the lower bound VSL estimate derived by OECD. If we use the unitary elasticity, it is likely to overestimated VSL for Turkey. We have found that the ECOTEC approach, which was developed for the derivation of VSL for EU candidate countries, predicts our country-specific VSL value very well (10 percent transfer error, "Very Good Fit") when we adopt their lower-bound VSL value. On the other hand, the VSLs derived by recent studies[6,20] significantly overestimate VSL for Turkey.

Benefit transfers in domestic setting are also implemented using both unit value transfers with income adjustments and function transfers from the original choice experiment study. Most of the transfers are successful with "Good Fit" or "Very Good Fit" levels of transfer errors. However, the transfer between Afşin-Elbistan and Kütahya-Tavşanlı resulted in the high transfer error because VSL estimates for these regions are quite different although the income levels are very similar to each other. This is a good case to point out the importance of conducting primary research especially when the risk factors are high in the region. On the other hand, if the background risks (and other socio-economic characteristics) and income levels are similar or moving in the same direction (the higher the income level, the higher the VSL), then we can conclude that the unit-value transfer with income adjustment derives satisfactory results for policy sites in Turkey. For practical convenience, we recommend the use of VSL estimate of 740,838 TL (in 2012 TL, Pooled data case) with an income elasticity of VSL of 0.5 for the domestic benefit transfers for VSL. The transfer errors from Pooled VSL to policy sites result in at most 41% transfer errors for all cases.

As for the function transfer practices, we confirm that the function transfers using just household income, age and gender variables work very well for the transfers from the sites with higher income to lower income levels (i.e. From Kütahya-Tavşanli to Afşin-Elbistan, from Ankara to Kütahya-Tavşanli and from Ankara to Afşin-Elbistan.) and the transfer errors are between 1 to 52% for the simple model (Model 1) and between 7 to 55% for the detailed model (Model 2). Hence, when we adopt the function transfers, we recommend conducting the transfers from higher to lower income sites. We also found that the there are no significant improvements in transfer errors even if we include more area-specific variables (i.e. individual health conditions, illness history, the use of coal in household heating). Therefore, the use of the basic set of demographic variables (Income, Age and Gender) results in as good as or even better transfer errors in our case. Hence, considering the cost of obtaining the detailed information in the policy sites, the use of function transfers with a simple set of demographic variables is recommended for practical use.

When we compare the transfer errors between unit-value transfer with income adjustment and a simple function transfer, we have found that the significantly better simple function transfer results from Kütahya-Tavşanli to Afşin-Elbistan and from Ankara to Afşin-Elbistan, while it was worse for the Ankara to Kütahya-Tavşanli transfer. In order to avoid the variabilities in transfer errors, we recommend the use of unit value transfers with income adjustment from pooled-data estimate in general to the policy site. However, when there is evidence to believe that the background mortality risk is significantly different between study and policy sites, we recommend (1) the use of simple transfer function with a basic set of demographic variables and (2) transfer from the higher to lower income sites. The function transfer may be preferred to the unit value transfer when the higher income level does not necessarily lead to higher VSL. Such cases could occur when the background

risk factors (i.e. air quality) are significantly different. Therefore, a careful investigation of policy sites before applying to the benefit transfer is necessary. Overall, our benefit transfer errors are small, within the range of "Very Good Fit" and "Good Fit" for most cases, and this result shows the promising potentials for the domestic benefit transfer practices using the result of our primary study.

Some limitations of the study should be noted. Since there is no other primary VSL study rather than Tekeşin and Ara (2014), we could not verify our recommendations based on the other estimates of VSL. The verification and the updates will be conducted once new VSL estimates are reported. Given the fact that the primary VSL estimates are rarely available especially in developing countries, benefit transfers have been conducted without the knowledge of "true" VSL and the transfer errors. This article intends to raise awareness of the potential errors in standard practices and provide the range of transfer errors given different transfer methods. Due to the unavailability of VSL estimates for different regions of Turkey, the exact transfer errors of the values reported in Table 8 cannot be verified. If there are unforeseen factors affecting VSL in the region, transfer errors might be larger than the "Good fit" level. We must wait for future primary VSL studies to be conducted in Turkey to identify such factors.

In general, VSL consists of a large proportion of entire health/environment related costs (lives lost) or benefits (lives saved). For example, the ratio of mortality and morbidity costs of air pollution related health evaluation project is approximately 90:10[5 24], and furthermore, such health cost reduction (= benefit) of the policy could justify the cost of health-improvement policies because of the magnitude of VSL. Hence, it is critical to select the most appropriate VSL value by choosing the best transfer method. It is also important tounderstand the size of the potential transfer errors when decision makers conduct sensitivity analysis.

We would like to summarize our recommendations we made in this article as our last remark. For international benefit transfer of VSL to Turkey, we recommend the unit-value transfer with income adjustment using the lower bound OECD value, using an income elasticity of VSL 2.0 – 2.5. As for the domestic benefit transfer within Turkey, we recommend the use of nit-value transfer with income adjustment with a base value = 740,838 TL (in 2012 TL) and the elasticity = 0.5. Although for some cases the transfer errors are smaller if we use the simple function transfer, the transfer error based on unit-value transfer with income adjustment is most likely within "Good fit". When the transfer is necessary between the sites with different background mortality risks, the function transfer with the basic demographic variables could improve the transfer results.

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