On the Benefit Transfers of the Value of a Statistical Life

Abstract: International and domestic benefit transfers are conducted for Turkey. For the international transfers, (1) unit-value transfer with income adjustment, (2) the method developed by ECOTEC (2001) for EU candidate counties and (3) VSL derived for Turkey by recent literature are examined. 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 2.0-2.5 the income elasticity of VSL is used. We recommend the use of unit-value transfer with income adjustment with base value = 740,838 TL and the elasticity = 0.5 for the domestic benefit transfer in Turkey. When the transfer is necessary between the sites with different background risks, the function transfer with a basic set of demographic variables could improve the transfer results when the transfer is made from the site with higher to the lower income.

Keywords: Value of Statistical Life (VSL), Benefit Transfer, Income Elasticity of VSL, Turkey

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1. Introduction

The estimations of VSL and the values of other health and environmental goods require the significant amount of time and money. However, for the policies and projects which could potentially affect people's mortality, health and environment, environmental impact assessments and cost-benefit analysis (CBA) should be implemented to justify the policies and projects. 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], CBA had to rely on the internationally transferred values. However, we could not know how accurate it reflected the true VSL for Turkey. Since we conducted a choice experiment to measure VSL for three areas in Turkey in 2012 [1], it is now possible for us to numerically evaluate the transfer errors when we use the suggested method by OECD and EU.

The value of statistical life (VSL) is one of the most critical factors which must be included 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 each individual. VSL is estimated using the people’s willingness to pay (WTP) for the reduction of mortality risks and is widely used in the areas of health, environment, transportation safety, food safety, among others around the world. For example, if the reduction of air pollutants (e.g. PM10 – Particulate matter with a diameter less than or equal to 10 micrometers) 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? In another example, if an installation of a child seat in a car results in a reduction of the mortality risk of the toddlers by onefourth, how much are people willing to pay for the child seat? VSL is calculated as WTP/Δrisk, or 600 TL/(1/10000) = 6,000,000 TL if the WTP is estimated as 600 TL for the first air pollution example. If a change in environmental or health policy impacts the premature mortality of the affected population, the benefits of such policy changes have to be clearly listed not only as a mere item, but as s the monetized value. In general, while the monetary costs of such policies can be readily derived as accounting costs, the benefits are often difficult to be clearly defined, rarely monetized and hence underestimated in policy assessments.

VSL is used to monetize the benefits of health/environmental policies. Suppose that the average PM10 in Ankara is 64 $\mu g/m^3$ currently and in order to meet the EU air quality standard for PM10 (40 $\mu g/m^3$), the government needs to implement multiple projects to reduce the pollution level. Given the dose-response function derived for PM10 [2][1], the premature mortality per 100,000 people is 6.72 per 10 $\mu g/m^3$ of PM10. In other words, if the government policy succeeds to reduce PM10 by 24 $\mu g/m^3$ (from 64 to 40 $\mu g/m^3$), 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) (Reference deleted for the review process), 445,161,184 TL (= 646 * 689104) welfare gain could be realized just from PM10 reduction part of this air pollution reduction policy. According to the studies conducted in US, over 80 percent of monetized benefits from US air pollution policies is accounted for 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 aims of this study are two folds: 1. to conduct international benefit transfer (Between

[1] Since the country-specific dose-response function is not available for Turkey, we used the value derived by [2].

Country Transfers) to calculate 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). Under both international and domestic settings, our research is expected to contribute to the better policy evaluations.

When we need to derive the country specific VSL, we either rely on a 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 and (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 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. The key component for this method is the income elasticity of WTP. On the other hand, 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 comparing to the unit value transfers. Meta-analysis derives a benefit function including the determinants of WTP and the study characteristics using the existing studies ([5]-[9], for example). The limitations and the potential biases of meta-analysis are discussed in [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 form of transfers which often require extra data and introduce further biases.

Income Elasticity of VSL is a key component for unit-value transfer with income adjustment. It is often assumed to be between 0.8 [10] and 1 ([11], [12] for the benefit transfers to developing countries), while [3] suggests that the elasticity of VSL is likely to be greater than 1.0 for the transfers to the developing countries. There are currently relatively small number of VSL studies available for developing countries [8, 13-18] and among the existing literature, the elasticity of VSL for developing countries are quite mixed. For example, [14] reports the elasticity of 0.55 for the case in India and [20] finds 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 [9] of 2.44 for Iran, [21] of 1.7 - 2.3 for Chili and 1.4 for China by [22]. [1] estimated the elasticity being approximately 0.5 for Turkey. [23] 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.

[1] conducted a choice experiment in 5 cities (Afsin, Elbisistan, Kutahya, Tavsanli and Ankara) in 3 areas (Afsin-Elbistan in Kahramanmaras province, Kutahya-Tanvsali in Kutahya province and Ankara) in Turkey in 2012 to estimate VSL for these areas. The population of each city are 84244, 139046, 101001, 0.56 million and 4.9 million in Afsin, Elbistan, Kutahya, Tavsanli and Ankara, respectively. In other words, small, medium and large-sized cities are respresented by Afsin-

Elbistan, Kutahya-Tavsanli and Ankara, respectively. The choice experiment[2] aims to reveal the people's willingness to pay for mortality risk reduction. They found VSL estimates for each study areas 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 Afsin-Elbistan, Kutahya-Tavsanli 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 without any individaul charactoristics. We found the income elasticity of VSL as 0.298, 0.626, 0.281 and 0.494 for Afsin-Elbistan, Kutahya-Tavsanli, Ankara and Pooled cases, respectively.

2. 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 [8] and the latest VSL calculation suggested by [11].

2.1. Unit Value Transfer with Income Adjustment

Unit value transfer with income adjustment is the most commonly used benefit transfer approach. [7] recommends 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. The base value to an individual country is adjusted by using unit transfer with income adjustment as follows:

[2] Attributes are Risk Type(Lung Cancer, Other Type of Cancer, Respiratory Disease, Traffic Accident), Affected Person (Own, One of the Children), Effective Date (Today, 1 Year Later), Risk Reduction for 1 year (1/10,000 ~ 8/10,000) and Price.

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

where p and s stand for policy and study site, respectively, Y is the PPP-adjusted GDP per capita and β indicates the income elasticity of VSL. Note that the income elasticity of VSL used here for between-country benefit transfer is different from the income elasticity of VSL we derived in Section 2 (within-country income elasticity of VSL) which will be used in Section 4. Converting $3.0 million (the base VSL for OECD member countries) and $3.6 million (the based 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)[3].

Using PPP-adjusted GDP per capita in current (2016) international dollars for OECD members ($37,517) and EU members ($35,241) as Y_S and $20640 for Turkey as Y_P ($\left(\frac{Y_p}{Y_S}\right) = 0.55$ for OECD and $= 0.59$ for EU), we can calculate VSL_P with four different income elasticities as below (Table 2). 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 OECD value and $1.37 million (β = 0.9) to $1.52 (β = 0.7) for 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 [24] unit value transfer with income adjustment works well only if we use OECD base value

[3] 2012 GDP per capita in PPP-adjusted current (2016) international dollar is used for the calculation of the Yp/Ys ratio. http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD (Accessed on August 1st, 2017)

with the high income elasticity of WTP (β =2.5). However, if we assume β = 1.0 as it is often assumed in the studies, the transfer errors are unacceptably high. If we use the lower bound values for VSL_S with OECD values, VSL_P 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.

<Insert Table 1 here>

Similarly, VSL can be derived for other candidate countries as well (Table 2). If we apply our finding about Turkey (use of OECD lower bound VSL value with high (2-2.5) income elasticity of VSL) to other EU candidate countries, except for Iceland due to a large difference in income level, our suggested VSL for Serbia, former Yugoslavia Republic of Macedonia and Montenegro is between \$ 0.1 to 0.25 million while for Albania and Bosnia-Herzegovina, it is between \$ 0.08 – 0.14 million (PPP adjusted 2012 USD).

<Insert Table 2 here>

In summary, when benefit transfer with income adjustment is used to transfer either OECD or EU27 VSL values to EU candidate countries, it is recommended to use OECD lower bound value with 2 – 2.5 income elasticity where appreciable, or use EU27 base value with 2.5 income elasticity of VSL for EU wide projects.

2.2. ECOTEC Approach for EU Candidate Countries

[25] approach does not involve income elasticity of VSL and suggests the use of PPP weighting to adjust the base value for EU candidate countries. It suggests the use of VSL for EU countries in the range of € 0.7 million - € 2.5 million with a central value of € 1 million for the 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[4] and $ 0.776 million in 2012 dollars[5]. 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 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).

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

[11] provides a list of VSL for close to 200 countries including Turkey. They use US VSL value ($9.631 million) as the base value, the income elasticity as 1.0 and each country's GNI (Gross

[4] Calculated based on OECD data base (http://data.oecd.org/price/inflation-cpi.htm, accessed on July 1st, 2014). The average CPI for EU-15 is calculated for 1999 and 2012, and the inflation is derived as 33.27%.
[5] The exchange rate between Euro and USD as of July 1st 2012 is used (1 Euro = 1.266 USD).

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.

[8] derived the transfer function for developing countries using meta-analysis as

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

where GDP per capital is in 2005 PPP-adjusted USD. Since 2012 GDP per capita for Turkey is \$ 20639.86 in 2016 PPP-adjusted USD, we can derive the suggested VSL using this transfer function with GDP per capital: \$ 16801.47 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 [11]. Hence, the transferred VSLs using the results of these recent studies may be overestimated.

3. Domestic Benefit Transfers in Turkey

In this section, within-country benefit transfer for Turkey is examined. In section 4.1, we will examine the accuracy of unit value transfer with income adjustment using our primary data while section 4.2 conduct benefit function transfer between these three study areas in order to identify the potential transfer errors to the cities where there is no VSL estimate. Section 4.3. 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[6] are used to test the feasibility of

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[6] Based on 2011 Census by TUIK (http://www.turkstat.gov.tr/PreTablo.do?alt_id=1047) Population and Housing Census, 2011. (accessed on June 30th, 2014).

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.

3.1. Unit Value Transfer with Income Adjustment

Unit value transfers are conducted among three study areas in Turkey. The mean monthly household income of our sample are 1770, 1825 and 2796 TL for Afsin-Elbistan, Kutahya-Tavsanli 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 $e = \frac{VSL_{S\_BT} - VSL_{S\_TRUTH}}{VSL_{S\_TRUTH}} \times 100\%$ where VSL_{S_BT} is the transferred value of VSL using benefit transfer with income adjustment while VSL_{S_TRUTH} is the VSL estimate from the primary study (Table 6).

Except for the transfer from Afsin-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 of the cases. The reason for the unsuccessful transfer between Afsin-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 Afsin-Elbistan is significantly higher than the one in Kütahya-Tavşanlı mainly due to the higher background health risk in Afsin-Elbistan. The benefit transfer with income adjustment does not take into account 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_{S_TRUTH} including the direction (smaller or greater than the base VSL). Based on the estimated transfer errors reported in Table 6, 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 among others. 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.

<Insert Table 6 here>

3.2. Function Transfer

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 7.

< Insert Table 7 here>

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 Turkish Statistical Institute (TUIK).

$$V = \beta_0 ASC\_SQ + \beta_{PRICE}PRICE + (\beta_{RISK} + \beta_{HHINC}HHINC + \beta_{AGE}AGE + \beta_{AGE2}AGE^2 + \beta_{SEX}GENDER)RISK + \beta_1 DATE + \beta_2 LUNG + \beta_3 CANCER + \beta_4 TRAFFIC \quad (Model 1)$$

Model 2 includes more detailed variables which are linked to health and environmental risks. Although UNIV and OVER65 variables are available from TUIK, other variables are not readily available. Simple survey may be necessary to be conducted to collect these 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.

$$V = \beta_0 ASC\_SQ + \beta_{PRICE}PRICE + (\beta_{RISK} + \beta_{UNIV}UNIV + \beta_{OVER65}OVER65 + \beta_{ASTCB}ASTCB + \beta_{CVSAC}CVASC + \beta_{COAL}COAL + \beta_{GDHLTH}GDHLTH)RISK + \beta_1 DATE + \beta_2 LUNG + \beta_3 CANCER + \beta_4 TRAFFIC \quad (Model 2)$$

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

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

for Model 2.

By using average values for each study area (Table 8), the VSL for policy sites are calculated as well as the transfer errors using the true estimated VSL.

<Insert Table 8 here>

The derived transfer errors using Model 1 and Model 2 are reported in Table 7 and 8, respectively. Transfer errors are very small for the transfers from Kutahya-Tavsanli to Afsin-Elbistan (|transfer error| = 1%) and from Ankara to Afsin-Elbistan (5%) using Model 1 and from Ankara to Kutahya-Tavsanli (7%) using Model 2. However, the other transfers are similar or worse than the errors derived under the benefit transfers with income adjustment. Generally speaking, the transfers from the higher income to the lower income sites work better compared to the opposite cases. 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. Kutahya-Tavsanli => Afsin-Elbistan, Ankara => Afsin-Elbistan cases).

<Insert Table 9 here>

<Insert Table 10 here>

3.3. Transfers from Study Areas to Other Areas in Turkey

Given the findings from Sections 4.1 and 4.2, we now conduct the benefit transfer using the unit value transfer with income adjustment using the regional average monthly household income (Table 11). As we recommended in Section 4.1, we use the base VSL as 740,838 TL with the income elasticity of VSL of 0.5. As reported in Table 12, the transferred values using the income elasticity of VSL as 0.5 ranges from 690,803TL (TR9 East Black Sea) to 867411 (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.

< Insert Table 11 here>

<Insert Table 12 here>

4. Discussion and Conclusions

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 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 ([8,11]) 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 a primary research especially when the risk factors are high in the region since their VSL estimate could be significantly higher than other regions even if the income levels are similar. On the other hand, if the background risk (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 the practical convenience, we recommend the use of VSL estimate of 740,838 TL (in 2012 TL, Pooled data case) with the income elastic of VSL of 0.5 for the domestic benefit transfers for VSL. The transfer errors from Pooled VSL to the 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 the lower income level (i.e. From Kutahya-Tavsanli to Afsin-Elbistan, from Ankara to Kutahya-Tavsanli and from Ankara to Afsin-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 to conduct the transfers from the higher to the lower income sites. We also found that the there is no significant improvements in the 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 the 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 results from Kutahya-Tavsanli to Afsin-Elbistan and from Ankara to Afsin-Elbistan while it was worse for Ankara to Kutahya-Tavsanli transfer. Hence we recommend the use of unit value transfer with income adjustment based on pooled-data estimate in general. However, when more precise transfer is desired, 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 necessary leads to the higher VSL. Such case 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 of the cases, and this result shows the promising potentials for the domestic benefit transfer practices using the result of our primary study.

6. Bibliography

[1] Deleted for Review Process

[2] Ostro, B. Estimating the Health Effects of Air Pollutants: A Method with an Application to Jakarta; Policy Research Working Paper 1301; The World Bank: Washington, WA, USA, 1994

[3] Hammitt JK, Robinson LA: The Income Elasticity of the Value per Statistical Life Transferring Estimates between High and Low Income Populations. *J. Benefit-Cost Analysis 2011*, 2(1): Article 1. DOI: 10.2202/2152-2812.1009.

[4] Navrud, S and R. Ready (eds.) 2007: Environmental Value Transfer: Issues and Methods.Springer, Dordrect, The Netherlands, 290 pp.

[5] Lindhjem, H., Navrud, S., Biausque, V., Braathen, N.A. (2010), Meta-analysis of stated preference VSL studies: Further model sensitivity and benefit transfer issues. OECD, Paris. Available at www.oecd.org/env/policies/vsl.

[6] Lindhjem, H., Navrud, S., Braathen, N. A., Biausque, V. (2011), Valuing Mortality Risk Reductions from Environmental, Transport, and Health Policies: A Global Meta-Analysis of Stated Preference Studies. *Risk Analysis*, 31: 1381–1407. doi: 10.1111/j.1539-6924.2011.01694.x

[7] OECD (2012), Mortality Risk Valuation in Environment, Health and Transport Policies, OECD Publishing. Available at http://dx.doi.org/10.1787/9789264130807-en

[8] Milligan, C., Koppa, A., Dahdaha, S., Montufarba, J. (2014). Value of a statistical life in road safety: A benefit-transfer function with risk-analysis guidance based on developing country data. Accident Analysis and Prevention 71:236–247

[9] Brajer, V., Rehmathan, M. (2003), From Diye to Value of Statistical Life: A Case Study for the Islamic Republic of Iran. Available online: http://iwlearn.net/publications/misc/caspianev_brajer.pdf/view (accessed online June 1st 2014).

[10] OECD (2015). Economic cost of the health impact of air pollution in Europe: Clean air, health and wealth. WHO Regional Office for Europe, Copenhagen: WHO Regional Office for Europe.

[11] Viscusi, W. Kip and Masterman, Clayton J. (2017). Income Elasticity and the Global Value of a Statistical Life. Vanderbilt Law Research Paper No. 17-29.

[12] Miller, T.R., (2000). Variations between countries in values of statistical life. *Journal of Transport Economics and Policy* 34, 169–188.

[13] Vassanadumrongdee S, Matsuoka S. Risk Perceptions and Value of a Statistical Life for Air Pollution and Traffic Accidents: Evidence from Bangkok, Thailand. Journal of Risk and Uncertainty. 2005; 30(3):261-87

[14] Bhattacharya, S., Alberini, A., Cropper, M.L. (2007). The value of mortality risk reductions in Delhi, India. *Journal of Risk and Uncertainty.* 34, 21–47.

[15] Krupnick, A., S. Hoffmann, B. Larsen, X. Peng, R. Tao,and C. Yan. 2006. The willingness to pay for mortality risk reductions in Shanghai and Chongqing, China.Washington, D.C.: Resources for the Future

[16] Mahmud, Minhaj. "On the contingent valuation of mortality risk reduction in developing countries." Applied Economics, 2008: 171-181

[17] Hoffman, S., Qin, P., Krupnick, A., Badrakh, B., Batbaatar, S., Altangerel, E., Sereeter, L."The willingness to pay for mortality risk reductions in Mongolia." Resource and 36 Energy Economics, 2012: 493-513

[18] Robinson, L.A., Hammitt, J.K. (2009) The value of reducing air pollution risks in Sub-Saharan Africa. Prepared for the World Bank under subcontract to ICF International. (Available from http://www.regulatory-analysis.com/robinson-hammitt-air-pollution-africa.pdf)

[19]Alolayan, M.A., Evans, J.S., Hammitt, J.K. (2017) Valuing Mortality Risk in Kuwait: Stated-Preference with a New Consistency Test. Environmental and Resource Economics. 66: 629-646. DOI 10.1007/s10640-015-9958-1

[20] Hammitt, J.K., Zhou, Y. (2006). The economic value of air-pollution-related health risks in China: A contingent valuation study. *Environmental and Resource Economics,* 33, 399–423.

[21]Bowland B.J., Beghin, J.C. (2001). Robust estimates of value of a statistical life for developing economies. *Journal of Policy Modeling*, 23: 385-396.

[22] Wang, H. and J. Mullahy. 2006. "Willingness to Pay for Reducing Fatal Risk by Improving Air Quality: A Contingent Valuation Study in Chongqing, China." Science of the Total Environment. Vol. 367, pp. 50-57.

[23] Narain, U., Sall, C. (2016). Methodology for valuing the Health Impacts of Air Pollution: Discussion of Challenges and Proposed Solutions. World Bank, Washington DC.

[24] OECD (2011), Valuing Mortality Risk Reductions in Regulatory Analysis of Environmental, Health and Transport Policies: Policy Implications, OECD, Paris. (Available online :http://www.oecd.org/env/policies/VSL, accessed on June 1st 2014).

[25] Ecotech (2001), The Benefits of Compliance with the EU Environmental Acquis for the Candidate Countries. Available at http://ec.europa.eu/environment/archives/enlarg/pdf/benefit_long.pdf

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.

Table 2. Calculated VSL for Other Candidate Countries

			Yp/Ys	0.7	0.9	1	1.5	2	2.5
Albania	OECD	base value	0.28	1.49	1.16	1.02	0.54	0.29	0.15
	EU27		0.30	1.89	1.49	1.32	0.72	0.39	0.22
Bosnia & Herzegovina	OECD		0.27	1.46	1.12	0.99	0.51	0.27	0.14
	EU27		0.29	1.85	1.44	1.27	0.68	0.37	0.20
Iceland	OECD		1.08	3.84	3.90	3.93	4.08	4.24	4.40
	EU27		1.15	4.86	5.00	5.07	5.43	5.82	6.24
Serbia	OECD		0.35	1.74	1.41	1.27	0.75	0.44	0.26
	EU27		0.37	2.21	1.81	1.64	1.00	0.61	0.37
Montenegro	OECD		0.37	1.81	1.49	1.34	0.82	0.50	0.30
	EU27		0.39	2.30	1.91	1.74	1.09	0.68	0.43
Macedonia, FYR	OECD		0.32	1.62	1.29	1.15	0.65	0.36	0.20
	EU27		0.34	2.06	1.65	1.48	0.86	0.50	0.29
Kosovo	OECD		0.23	1.29	0.95	0.82	0.39	0.19	0.09
	EU27		0.24	1.63	1.23	1.06	0.52	0.26	0.13
Turkey	OECD		0.55	2.39	2.12	2.00	1.48	1.10	0.82
	EU27		0.59	3.03	2.73	2.58	1.98	1.51	1.16
Albania	OECD	lower bound	0.28	0.75	0.58	0.51	0.27	0.14	0.08
	EU27		0.30	0.95	0.74	0.66	0.36	0.20	0.11
Bosnia & Herzegovina	OECD		0.27	0.73	0.58	0.51	0.27	0.14	0.08
	EU27		0.29	0.92	0.72	0.64	0.34	0.18	0.10
Iceland	OECD		1.08	1.92	1.95	1.96	2.04	2.12	2.20
	EU27		1.15	2.43	2.50	2.53	2.72	2.91	3.12
Serbia	OECD		0.35	0.87	0.71	0.64	0.38	0.22	0.13
	EU27		0.37	1.10	0.91	0.82	0.50	0.31	0.19
Montenegro	OECD		0.37	0.91	0.74	0.67	0.41	0.25	0.15
	EU27		0.39	1.15	0.95	0.87	0.54	0.34	0.21
Macedonia, FYR	OECD		0.32	0.81	0.64	0.57	0.32	0.18	0.10
	EU27		0.34	1.03	0.83	0.74	0.43	0.25	0.14
Kosovo	OECD		0.23	0.64	0.48	0.41	0.20	0.09	0.04
	EU27		0.24	0.81	0.61	0.53	0.26	0.13	0.06
Turkey	OECD		0.55	1.20	1.06	1.00	0.74	0.55	0.41
	EU27		0.59	1.52	1.36	1.29	0.99	0.76	0.58

Table 3. Unit Value Transfer with Income Adjustment, within Country Transfers for Turkey

FROM	TO	Income	Income Elasticity	VSLS	VSLP	VSLP (TRUTH)	Transfer Error
Afsin-Elbistan	Kutahya-Tavsanli	Sample Average = 1825/1770	0.1	854,420	857039	527,878	62%
			0.3		862300		63%
			0.5		867593		64%
			0.7		872919		65%
			1		880970		67%
Afsin-Elbistan	Ankara	Sample Average =2796/1770	0.1	854,420	894392	689,104	*30%*
			0.3		980033		*42%*
			0.5		1073874		56%
			0.7		1176701		71%
			1		1349694		96%
Kutahya-Tavsanli	Ankara	Sample Average =2796/1825	0.1	527,878	550885	689,104	**-20%**
			0.3		599951		**-13%**
			0.5		653387		**-5%**
			0.7		711582		**3%**
			1		808737		**17%**
Kutahya-Tavsanli	Afsin-Elbistan	Sample Average =1770/1825	0.1	527,878	526265	854,420	*-38%*
			0.3		523054		*-39%*
			0.5		519862		*-39%*
			0.7		516690		*-40%*
			1		511969		*-40%*
Ankara	Afsin-Elbistan	Sample Average =1770/2796	0.1	689,104	658307	854,420	*-23%*
			0.3		600780		*-30%*
			0.5		548281		*-36%*
			0.7		500369		*-41%*
			1		436235		*-49%*
Ankara-	Kutahya-Tavsanli	Sample Average =1825/2796	0.1	689,104	660324	527,878	*25%*
			0.3		606321		**15%**
			0.5		556734		**5%**
			0.7		511202		**-3%**
			1		449791		**-15%**
Pooled	Afsin-Elbistan	Sample Average =1770/2130	0.1	740,838	727248	854,420	**-15%**
			0.3		700812		**-18%**
			0.5		675336		*-21%*
			0.7		650787		*-24%*
			1		615626		*-28%*
Pooled	Kutahya-Tavsanli	Sample Average =1825/2130	0.1	740,838	729477	527,878	*38%*
			0.3		707275		*34%*
			0.5		685749		*30%*
			0.7		664877		*26%*

			1		634756		**20%**
		Sample Average	0.1		761271		**10%**
		=2796/2130	0.3		803842		**17%**
Pooled	Ankara		0.5	740,838	848793	689,104	*23%*
			0.7		896259		*30%*
			1		972480		*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 ($VSLp - VSLp\_{TRUTH}$)/$VSLp\_{TRUTH}$. 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).

Table 7. 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
	Demographic and attitudinal variables, interacted with ASC_SQ or RISK.
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

Table 8. Mean Values for Individual Characteristics

Variables	Afsin-Elbistan	Kutahya-Tavsanli	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

Table 9. 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 (TRUE)[2]	Transfer Error
Afsin-Elbistan	Kutahya-Tavsanli	-0.0064	0.3250	0.101	0.009	-0.0002	-0.047	843109	527,878	60%
Afsin-Elbistan	Ankara	-0.0064	0.3250	0.101	0.009	-0.0002	-0.047	1000412	689,104	45%
Kutahya-Tavsanli	Ankara	-0.0103	-2.837	0.646	0.151	-0.002	-0.288	1475633	689,104	114%
Kutahya-Tavsanli	Afsin-Elbistan	-0.0103	-2.837	0.646	0.151	-0.002	-0.288	842608	854,420	-1%
Ankara	Afsin-Elbistan	-0.0059	-0.367	0.086	0.040	-0.0006	-0.034	812380	854,420	-5%
Ankara-	Kutahya-Tavsanli	-0.0059	-0.367	0.086	0.040	-0.001	-0.034	799861	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 10. 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}_T	Transfer Error
Afsin-Elbistan	Kutahya-Tavsanli	-0.0066	0.841	0.669	-0.394	0.1682	0.344	-0.395	-0.3954	934459	527,878	77%
Afsin-Elbistan	Ankara	-0.0066	0.841	0.669	-0.394	0.1682	0.344	-0.395	-0.395	1334938	689,104	94%
Kutahya-Tavsanli	Ankara	-0.0108	1.045	1.198	-2.680	0.539	0.341	-0.718	-0.061	1194182	689,104	73%
Kutahya-Tavsanli	Afsin-Elbistan	-0.0108	1.045	1.198	-2.680	0.539	0.341	-0.718	-0.061	633403	854,420	-26%
Ankara	Afsin-Elbistan	-0.0059	0.503	0.327	-0.099	0.3836	0.018	-0.392	-0.314	388530	854,420	-55%
Ankara-	Kutahya-Tavsanli	-0.0059	0.503	0.327	-0.099	0.384	0.018	-0.392	-0.314	488350	527,878	-7%

Table 11. Average Monthly Household Income for Statistical Regions

	Mean Monthly Household Income
Afsin-Elbistan	1770
Kutahya-Tavsanli	1825
Ankara	2796
TURKEY	2215
TR1 Istanbul	2920
TR2 West Marmara	1911
TR3 Aegean	2312
TR4 East Marmara	2280
TR5 West Anatolia	2498
TR6 Mediterranean	1945
TR7 Central Anatolia	2041
TR8 West Black Sea	1905
TR9 East Black Sea	1852
TRA North East Anatolia	1688
TRB Central East Anatolia	1661
TRC South East Anatolia	1446

Table 12. Unit Value Transfer to Other Regions in Turkey

FROM	TO	Mean Income (STUDY) Mean Income (POLICY)	Income Elasticity	VSLS	VSLP
POOLED	TURKEY	2130	0.5	740,838	755,475
		2215	1		770,402
	TR1: Istanbul	2130	0.5	740,838	867,411
		2920	1		1,015,609
	TR2: West Marmara	2130	0.5	740,838	701,720
		1911	1		664,667
	TR3: Aegean	2130	0.5	740,838	771,840
		2312	1		804,140
	TR4: East Marmara	2130	0.5	740,838	766,480
		2280	1		793,010
	TR5: West Anatolia	2130	0.5	740,838	802,287
		2498	1		868,833
	TR6: Mediterranean	2130	0.5	740,838	707,935
		1945	1		676,493
	TR7: Central Anatolia	2130	0.5	740,838	725,195
		2041	1		709,883
	TR8: West Black Sea	2130	0.5	740,838	700,617
		1905	1		662,580
	TR9: East Black Sea	2130	0.5	740,838	690,803
		1852	1		644,146
	TRA: North East Anatolia	2130	0.5	740,838	659,507
		1688	1		587,105
	TRB: Central East Anatolia	2130	0.5	740,838	654,212
		1661	1		577,715
	TRC: South East Anatolia	2130	0.5	740,838	610,404
		1446	1		502,935