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Mikołaj Czajkowski
Milan Ščasný

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Study on Benefit Transfer in an International Setting. How to Improve Welfare Estimates in the Case of the Countries' Income Heterogeneity?

Mikołaj Czajkowski

Warsaw Ecological Economics Center
Faculty of Economic Sciences, University of Warsaw
miq@wne.uw.edu.pl

Milan Ščasný

Charles University Prague
Environment Center

Abstract

The paper aims at investigating the validity of benefit transfer in the case of transfers between countries highly heterogeneous in income, and demonstrates relative performance of different benefit transfer methods under these conditions. We examine how income elasticity of WTP varies in line with the levels of income in order to provide scientifically sound elasticity factor for adjusting transferred welfare estimates. In addition, we have noted that using site-specific measures of income substantially outperforms transfers based on GPD per capita. The results provide conclusions for the future benefit transfers between countries differentiated by income. The accuracy of benefit transfer is compared using equivalence testing following the TOSC test; a new, more informative way of reporting equivalence is proposed and developed, based on computing minimum tolerance level rather than specifying it a priori. The empirical studies are one of the first applications of virtually the same study settings and questionnaires in an environmental quality context, what supplements a few previously existing applications in health effects settings. Lake water quality valuation studies were conducted in two countries in transition – Poland and the Czech Republic – that reflected the earlier studies carried out in Norway and Germany. The use of the same questionnaires and scenarios allowed to control for survey artefacts that could possibly bias the willingness to pay. The welfare estimates collected at four different sites provided a wide base for testing the benefit transfer and comparing the performance of methods to improve the transfer accuracy. Finally, the guidelines for future applications have been offered, as particularly valuable for benefit transfers between countries highly heterogeneous in income.

Keywords:
benefit transfer, income heterogeneity, contingent valuation, water quality, equivalence testing, TOSC, convolutions, economies in transition

JEL:
Q51, Q53, Q25

1. Introduction

Acquiring monetary values for non-market goods and services by primary studies may be time-consuming and costly. One of the possible alternatives is applying benefit transfer, i.e. adjusting benefit estimates based on primary data collected at a different study site and applying it at the new, policy site. The method has been increasingly popular in the literature, since it is both faster and cheaper than carrying out new primary valuation studies (Champ et al. 2004). The development of benefit transfer techniques has also been facilitated by increasing availability of existing primary studies (Shrestha and Loomis 2003).[1] Despite all of above, however, the validity of benefit transfer in an international setting in general, and particularly between developed and developing countries or countries in transition, remains to large extent uncertain.

International benefit transfer, when study and policy sites are in different countries, introduces some unique challenges and problems. These include the necessity to correct for differences in income, currency, purchasing power parity, and possibly others (Ready and Navrud 2006). For these reasons it is probably safer to conduct benefit transfer within a country, than between countries, trying to control for all the differences. However, international benefit transfer remains desirable for at least two reasons: (1) it usually allows for a wider base of primary studies, and (2) remains especially important for less developed and transitioning countries, where good quality national primary valuation studies might simply not be available (Ready and Navrud 2006).

Transferred values can substantially differ from values acquired directly, from only a few, to as high as a few hundred percent (Morrison and Bergland 2006). There are numerous reasons for differences between equivalent welfare measures observed at two different sites. One of these reasons may be differences in methodology used by the two studies. The need for comparative studies is thus clear. Conducting the same valuation studies of the same environmental amenities using as similar settings as possible (the same valuation scenarios and questionnaires) is indispensible in this matter (Navrud 2004). Only such studies bring an opportunity to identify other potential sources of differences. Controlling for these differences may prove to be an effective way of improving benefit transfer. Our study offers one of the first of such comparisons for an environmental amenity (water quality). To date most of the few existing studies (e.g. Ready et al. 2004; Krupnick et al. 2006) implementing the same protocol focused on valuation of health effects. Our study offers one of the first of such comparisons for an environmental amenity, specifically for water quality.

Another reason for differences in welfare measures observed at two different sites is differences in income or wealth levels. This is especially important for transfers between countries at different stages of development. The objective of this paper is to examine the possibilities for controlling for these income differences. Since income can be statistically measured and its level is usually known *a priori* to an empirical study – it is one of the most important adjustment factors. The paper demonstrates how utilizing different methods of

[1] For a review of primary valuation studies databases see McComb et al. (2006).

accounting for income differences can allow a researcher to improve benefit transfer. In addition, our study provides evidence that using site-specific or region-specific income levels substantially outperforms the more usual indicator of income – GDP *per capita*.

Finally, we employ a recently proposed TOSC test (Johnston and Duke 2008) for verifying equivalence of welfare estimates, as opposed to their equality (Kristofersson and Navrud 2005). A new, more informative way of reporting equivalence levels is proposed. Instead of specifying an *a priori* acceptable transfer error (which may be highly context-specific) we propose estimating minimum acceptable transfer error that would allow for concluding of equivalence of the two values at the 5% significance level. We argue that this new approach is more informative than specifying error rates only, since it incorporates information about variance and possibly covariance of the two value estimates.

The empirical studies were conducted in water quality setting, specifically lakeeutrophication. We aimed to analyse validity of transferring values between Western European and Eastern European Countries. Since the two neighbouring countries – Poland and the Czech Republic – are both economies in transition, with similar political and cultural history, the benefit transfer in this setting proved to be an efficient and interesting exercise. We utilized a contingent valuation survey applied for two lakes in Norway (Magnussen 1997). Similar questionnaire was also applied for two German lakes (Muthke and Holm-Mueller 2004) and two other Norwegian lakes (Bergland et al. 1995), some differences between the latter two studies made them less comparable, however. The sites and scenarios in our case studies used virtually the same contingent valuation scenario and questionnaire as the study by Bergland et al. (1995) thus avoiding any methodological differences, which were the shortcoming of the comparative study of Muthke and Holm-Mueller (2004).

The paper is organized as follows. Section 2 provides an overview of previous studies examining the validity of benefit transfer, with particular interest in developing and transitioning countries. Section 3 reviews the methods and presents the vital research questions. Section 4 describes empirical studies, while the next section reports the results of benefit transfer exercises. In the last section the results are discussed, and conclusions for future benefit transfers are given.

2. Previous studies

Metaregressions of the primary valuation studies usually find statistically significant effects of factors including methodology, commodity definition, payment vehicle, elicitation method and others (Loomis and Rosenberger 2006). For this reason benefit transfer testing is best conducted by using the same valuation scenario and possibly even the same questionnaire at all sites. There are several studies applying this approach, most of which were testing benefit transfer possibilities between health effects in well developed countries. The studies using the same contingent valuation (CV) questionnaire included applications in health impacts of UV exposure (Bateman et al. 2005), health effects related to air quality in five European countries (Ready et al. 2004), two cities of close proximity but different countries (Rozan 2004), or two

cities of the same country (Braun-Kohlová and Ščasný 2006), in mortality risk in three European countries (Alberini et al. 2006a)[2], or in life extension in nine European countries (Desaigues et al. 2006). The studies applying the same choice experiment (CE) questionnaires at different sites of the same country concerned landscape attributes (Colombo and Hanley 2008), land use (Johnston 2007), non-use value of wetlands (Morrison et al. 2002), farm and forest preservation (Johnston and Duke 2007; Johnston and Duke 2008), water quality (Hanley and Black 2006; Hanley et al. 2006b; Hanley et al. 2006a) and off-site effects of soil erosion (Colombo et al. 2007). An example of within-country application of the same CE questionnaire was provided by Brouwer and Bateman (2005) who elicited the WTP for solar UV exposure influence on health.

International benefit transfer remains a reasonable alternative in less developed countries because of both the tighter budget constraint and the abundance of the primary valuation studies in developed countries. However, there have been only a few studies testing benefit transfer validity in a developing or transitioning country setting. In a developing-to-developing country setting we were able to identify only two studies which applied the same questionnaire. They concerned coastal water quality in two coastal cities of Costa Rica (Barton 2002), and air pollution valuation in two big cities in Egypt and Morocco (Abou-Ali and Belhaj 2005)

Similarly, evidence is rather scarce for benefit transfers between developed and developing countries. Alberini et al. (1997) elicited WTP for avoiding ill health episodes in Taiwan, and compared the results with two similar[3] US studies . Chestnut et al. (1997) conducted valuation study of ill health episodes in Bangkok (Thailand) and also compared the results with the US studies. These both studies however, used quite different scenarios or survey instruments.

Most notably, Barton and Mourato (2003) compared WTP to avoid ill health caused by contaminated seawater between Portugal and Costa Rica using the same survey instrument. To our knowledge this remains the only study testing international benefit transfer between developed and developing countries using virtually the same setting. In addition, the vast majority of the above studies focused on transferring values of health effects, rather than environmental amenities. There is also no empirical study testing validity of transfer to the new EU member-states, either from the former member-states or between other post-communist countries which joined the EU in the last 5 years. Clearly more research seems to be needed in this fast growing field to address the limitations and improve the benefit transfer between countries with substantial income differences.

[2] The questionnaire was similar to that applied earlier in Canada and the USA (Krupnick et al. 2002; Alberini et al. 2004), and later on in Italy and the Czech Republic (Alberini et al. 2006b). Benefit transfer between six countries using similar protocol was performed by Krupnick et al. (2006).

[3] There were some differences in the survey instrument and the episodes were not exactly the same.

3. Methods and Research Agenda

Benefit transfer consists in adopting existing estimates from the 'study sites' to new 'policy sites'.[4] The by far the most common approach of 'value transfer' is based on transferring original results from a 'study site' directly to a 'policy site', with adjustments of the existing values for inconsistency in time (Navrud, 2004), currency (Brouwer and Bateman 2000) or income (Navrud and Ready 2007).

Similar approach of 'function transfer' consists in transferring entire demand or WTP functions (Loomis 1992). This approach is believed to allow for control of the differences between the study and the policy sites, because such differences are explicitly accounted for. An implicit assumption, however, also results in a potential drawback of this approach – i.e. the same explanatory variables and function parameters at study and policy sites are assumed. Obviously, this assumption does not have to be satisfied, especially for regions differing by many characteristics (Downing and Ozuna 1996; Rosenberger and Stanley 2006).

Finally, another method for benefit transfer is meta-analysis of existing valuation studies to provide appropriate value for a policy site.[5,6] Meta-analysis is also a way which allows for controlling various sites and methods, thus giving better estimates (Shrestha and Loomis 2003). This is important, because many methodological characteristics of the primary studies, such as commodity definition, market and sample characteristics, valuation method used, payment vehicle, or elicitation method (Johnston et al. 2005), turn out to be statistically significant explanatory variables of the welfare measures. Due to the ubiquity of methodological factors' effect on value measures (Loomis and Rosenberger 2006), appropriate testing of the validity of benefit transfer requires using as similar settings, methods, scenarios and questionnaires as possible.

In many benefit transfer applications the study and policy sites are not fully compatible with respect to time, currency, and population's income. Therefore, welfare estimates need to be properly adjusted for these discrepancies. Differences in price levels are usually corrected for using consumer price index (Ready and Navrud 2006)[7,8], while different currencies are

[4] See Wilson and Hoehn (2006) for a comprehensive review of development of benefit transfer applications.

[5] This applies to both traditional meta-analysis (e.g. Jacobsen and Hanley forthcoming) and Bayesian meta-regression framework (Brundson and Willis 2003; e.g. Moeltner et al. 2007).

[6] We refer the reader to Navrud and Ready (2007) for a review of benefit transfer techniques and Morrison and Bergland (2006) for a review of benefit transfer types. Some other benefit transfer approaches not mentioned above include expert judgement methods (Brookshire and Neill 1992; Bergstrom and De Civita 1999; Bergland et al. 2003), and 'structural benefit transfer' method (Smith et al. 2002; Smith et al. 2006).

[7] A consumer price index (CPI) is a measure of the average price of consumer goods and services purchased by households in a country. In the European Union, the Harmonised Index of Consumer Prices (HICP) seems to be preferred. HICP differs from CPI in two main respects: (1) it incorporates rural consumers into the sample with appropriate weighting, and (2) it excludes owner-occupied housing ('rental-equivalent' costs) from the basket of goods.

[8] Another issue resulting from time differences of two studies corresponds to time stability of the estimates. See Brouwer and Bateman (2000) for discussion.

converted using market (nominal) exchange rate. However, similar market goods may cost different amounts of money in different countries – the relationship formally illustrated by Ready et al. (2004). To account for these differences purchasing power parity (PPP) corrected exchange rate is preferable.

Additionally, differences in values may come from divergence in income between two sites. This may be to a lesser extent problem for within country benefit transfer, or international benefit transfer between countries where average income levels are comparable, however, the issue may become critical in benefit transfer between countries heavily differentiated in income (Ready and Navrud 2006; Wilson and Hoehn 2006). The possible effect of income differences might be controlled for by using income elasticity of WTP approach, following the formula:

$$\widehat{WTP_{PS}} = WTP_{SS}\left(\frac{\overline{I_{PS}}}{\overline{I_{SS}}}\right)^{\varepsilon} \tag{1}$$

where WTP_{SS} is the willingness to pay observed at the study site, $\widehat{WTP_{PS}}$ is the WTP transferred (WTP estimated for the policy site), and $\overline{I_{SS}}$ and $\overline{I_{PS}}$ are mean income levels at the study and policy sites respectively. The ε represents income elasticity of WTP between the income levels observed at the two sites.

Even though some evidence indicates that environmental goods might be luxury goods, implying income elasticity of demand to be higher than one (Ghalwash 2008), Flores and Carson (1997) show that the relation between income elasticity of demand and income elasticity of WTP is not straightforward, and in case of rationed (public) goods knowledge of the one does not allow to draw conclusions on the other. A considerable number of studies provide evidence that income elasticity of WTP for environmental goods may be less than one. This is supported by Kriström and Riera (1996), Hökby and Söderqvist (2003), and Jacobsen and Hanley (forthcoming), which all show, that income elasticity of WTP ranges usually between 0 and 1. This range interval has been also observed in a study performed in a transitioning country (Latvia); Ready et al. (2002) report the mean income elasticity of WTP for surface water quality to be 0.59.

3.1. Validity of Benefit Transfer

Even after correcting for all the above sources of differences the WTP estimates of the study and policy sites may vary. There are many reasons for this, one of them being the accuracy of benefit transfer partially conditional upon the errors contained in original valuation studies (Wilson and Hoehn 2006). In order to measure transfer errors of benefit transfer the formulas originally proposed by Kirchhoff et al. (1997) may be simplified to cover both value and function transfer:

$$E_{TR} = \frac{WTP_{\text{transferred}} - WTP_{\text{observed}}}{WTP_{\text{observed}}} \tag{2}$$

A review of empirical literature indicates, that the majority of transfer errors is in the range of 0 –200% (Hanley et al. 2006a; Morrison and Bergland 2006; Rosenberger and Stanley 2006). It seems safe to conclude, that benefit transfers with absolute transfer errors of below 30-50% are considered successful.

Several approaches have been proposed for testing benefit transfer validity. The most common approach was testing equality of welfare measures. The null hypothesis of these tests may be formulated as:

$$H_0 : WTP_{\text{observed}} = WTP_{\text{transfered}} \tag{3}$$

i.e. the observed willingness to pay $\left(WTP_{\text{observed}}\right)$ is equal to the transferred willingness to pay $\left(WTP_{\text{transfered}}\right)$, which is based on appropriately adjusted primary study conducted elsewhere.

There are several ways in which the hypothesis given by equation (3) may be tested. Simple tests include testing equality of central tendency (usually means), equality of variances or equality of entire empirical distributions of WTP. Some of the studies used overlapping confidence intervals of welfare estimates following Park et al. (1991). This approach was, however, demonstrated to be too conservative and thus understating true confidence intervals; Poe et al. (1994; 1997; 2005) proposed an alternative non-parametric approach employing convolutions technique.

Another way of testing the validity of benefit transfer was proposed by Kristofersson and Navrud (2005). Instead testing the equality of welfare estimates, testing their equivalence is proposed. This is the result of a recognition that the values estimated in two different studies are supposed to vary. Instead of testing the hypothesis formalized in (3) the null hypothesis instead becomes:

$$H_0 : \left|WTP_{\text{transfered}} - WTP_{\text{observed}}\right| \geq D \tag{4}$$

where D is the maximum difference that is acceptable in a particular application. Rejecting this null hypothesis at a selected significance level (e.g. $\alpha < 0.05$) allows for conclusion that the two estimates are mutually equivalent (within the specified tolerance level, which can be based on a maximum acceptable transfer error).

Testing equivalence of two WTP estimates was originally proposed by two one-sided *t*-tests (TOST). This method was applied in environmental valuation setting by Kristofersson and Navrud (2005), Muthke and Holm-Mueller (2004), Hanley et al. (2006b), Colombo et al. (2007) and Johnston (2007). However, the *t*-test assumes normality of the distributions of the two estimates. This does not have to be the case for many functional forms of WTP distributions used in stated preference methods.

Instead, Johnston and Duke (2008) proposed the two one-sided convolutions test (TOSC), based on the method of testing statistically significant difference of two empirical distributions proposed by Poe et al. (1994; 2005). This non-parametric method remains robust irrespective of types or independency of the two distributions. This seems a very advantageous characteristic, especially in case of benefit transfer applications.[9]

4. The empirical study

In order to investigate validity and propose ways to improve performance of benefit transfer between well developed and transitioning countries, two new empirical studies were conducted in Poland and the Czech Republic. Both studies applied contingent valuation method utilizing the same scenario and the same questionnaire which was originally used by Magnussen (1997) for two Norwegian lakes. The application of the same setting was introduced in order to control for artefacts of methodological differences that could get reflected in welfare estimates, and to allow for benefit transfers within a reasonably big database of four studies using the same questionnaires, the two of which were conducted in Eastern European countries.

Interestingly, two other studies used similar questionnaire and setting. They were applied to two additional Norwegian lakes (Bergland et al. 1995) and two German lakes (Muthke and Holm-Mueller 2004). However, it is noteworthy that even though the authors used the studies to compare welfare estimates (Muthke and Holm-Mueller 2004) there were some substantial differences between the studies. The German study differed with respect to elicitation method (double bounded dichotomous choice was used); in addition, it was aimed at measuring equivalent variation (willingness to pay to prevent degradation). The Norwegian study by Bergland et al. (1995), apart from valuing changes in water quality levels, was aimed at valuing maintenance of footpaths and some elements of biodiversity conservation. For this reason we did not use the results of these two studies for comparisons, since it would not allow us to control the methodological differences.

The contingent scenario was based on a hypothetical improvement of water quality in a highly euthrophied lake. Water quality was classified using five-level scale based on total phosphorus content, with reference to average levels typical for geological and natural

[9] In case when the two distributions are correlated this requires accounting for in generating empirical distributions, does not, however, influence the procedure of conducting the convolutions test.

conditions in each country.[10] Each class was described by proxies such as environmental living conditions for water animals, occurrence of algae, and possibilities of recreational use (swimming, water sports, recreational fishing). The scope of environmental change was an improvement in water quality by 1 or 2 classes. The payment vehicle used in the questionnaire was an increase of sewage charge paid by respondent's household. For elicitation of WTP values a payment card was employed.

Two lakes selected for the study were Łęgowskie Lake in Poland and Máchovo Lake in the Czech Republic.[11] The study sites were chosen to match the Norwegian original and reflect the lakes' characteristics with regard to their location, pollution level and the source thereof.

The questionnaires, as prepared in the national languages, reflected the original one as closely as possible, and were developed with extensive focus groups and pilot study pretesting. The main face-to-face surveys were conducted in October – November 2005 on random samples of households in towns and villages in direct vicinity of each lake. To boost the response rate, the local municipal authorities were engaged in preparing information for the local population about the survey. There were 430 valid observations in total, 202 from Polish survey and 228 from the Czech one. Analysis of socio-demographic data from both the Czech and the Polish survey allows to draw a conclusion of high representativeness of both samples (age, household members, incomes were close to the regional averages).

Protest zero responses were identified and removed from the samples if a respondent chose the 'not willing to pay anything' option, and simultaneously stated that water quality is important to his/her household, however it is others' responsibility to pay for the water quality improvement.[12] All the studies used the same protest zero response identification criteria.

Several modelling approaches were applied to estimate the mean willingness to pay for improvements of 1-class and 2-class of water quality $\left(WTP_1 \text{ and } WTP_2 \text{ respectively}\right)$. These included normal, logistic, lognormal, and Weibull distributions of WTP (Haab and McConnell 2003). In addition, to account for a considerable ratio of responses identified as legitimate zero WTP the spike model with an exponential bid function was applied (Kriström 1997). Following Bateman et al. (2004) constant only bid functions were estimated. Different approaches were compared using the Vuong test (Vuong 1989) and the distribution-free test (Clarke 2007), what allowed to chose the spike model as the closest to the true specification. The welfare measures in EUR^{2008} – after the adjustments by HICP and nominal exchange rate – are summarized in Table 1. The confidence intervals were estimated using parametric bootstrapping following Krinsky and Robb (1986) method with 10^5 repetitions.

[10] These include depth, volume, water exchange rate, catchment area, turbidity, dissolved particulate matter, light penetration and other factors which are typical for natural conditions of the lakes in each country. A five level water eutrophication classification was created to classify the lake in comparison to the average national conditions.

[11] The process of selecting the lakes, gathering the data about phosphorus levels, and preparation of the maps used in the questionnaire were all carried out in cooperation with nationally recognized water pollution experts.

[12] There were 12% protest responses removed from the Czech sample and 21% from the Polish one.

5. Benefit transfer results

In order to test the validity of benefit transfer and provide evidence for research questions several benefit transfer techniques were applied. The WTP estimates were adjusted for differences in time using HICP. Both market and PPP-corrected exchange rates were used in order to compare the relative performance of the two approaches. In addition, we controlled for income differences using income elasticity approach, where income was approximated by both *per capita* GDP of the country or mean household income of each sample. Finally, a benefit function transfer technique was applied.

The studies chosen for benefit transfer analysis provided the estimates of WTP for 1 or 2-class water quality improvements in four lakes located in three different countries. This allowed for 12 different benefit transfer possibilities, of which eight 8 were between developed and transitioning countries, and 4 between transitioning countries. Thus, each study was both – a 'policy site' (to which welfare estimates were transferred from all the other sites) and a 'study site' (which was used to provide transfer values for all the other sites).

In order to conduct value transfers all the estimates were inflated to 2008 using HICP, and expressed in EUR using market exchange rate or PPP-corrected exchange rate. The results are summarized in Table 1.[13]

Table 1: Welfare estimates and 95% confidence intervals

Study site	EUR^{2008} (market exchange rate)		EUR^{2008} (PPP-corrected exchange rate)	
	WTP_1	WTP_2	WTP_1	WTP_2
Łęgowskie Lake (PL)	7.41 6.33 – 8.50	9.77 8.30–11.24	12.94 11.05 – 14.84	17.06 14.50 – 19.63
Macha Lake (CZ)	18.02 15.73 – 20.29	26.06 22.87 – 29.24	30.74 26.84 – 34.62	44.47 39.02 – 49.90
Lagenvassdraget (NO)	119.92 85.89 – 154.06	–	107.60 77.07 – 138.24	–
Ånøya and Gaustadvatnet (NO)	90.54 62.38 – 118.78	–	81.24 55.98 – 106.58	–

The differences between nominal value estimates are relatively high; the mean absolute transfer error is 366%, if market exchange rate is used. The differences are less evident for PPP-corrected exchange rate – in this case the average absolute transfer error is 200%. This

[13] For comparison, WTP estimates provided by Muthke and Holm-Mueller 2004 study are 75.10 EUR for 1-class improvement and 83.7 EUR for 2-class improvement in Guestrower-Seen, and 105.7 EUR and 130.8 EUR respectively in Ville-Seen (all in purchasing power parity at 2008 price level).

allows for the first conclusion that generally international transfer of PPP-corrected welfare measures performs better than a simpler, market exchange rate approach. Thus controlling for differences in average price levels proves significant in case of international benefit transfer.

However, the average transfer error of 200% is highly differentiated. While the average transfer error between developed and transitioning countries is 247%, it is 104% for the transfers between transitioning countries. This indicates that differences in income might not have been fully accounted for.

To account for possible differences in income we applied the income elasticity approach described above. However, selecting appropriate value of income elasticity is not a straightforward exercise. There are at least two reasons for this. Firstly, the income elasticity of WTP at the study site would usually not be available for a researcher. More importantly, there is a growing body of research demonstrating that income elasticity of WTP needs not to be constant. So far the literature does not provide any evidence on how income elasticity of WTP would change with such substantial changes of income.

Importantly, Ready et al. (2002) show, that point estimates of income elasticity in a transitioning country may increase, and approach the unity for higher quantiles of income. This is in line with other results, showing that income elasticity may be increasing along with the level of income (Hansen et al. 1996; Alberini et al. 2006a). This implies that if incomes in transitioning or developing countries were increased, so would be the income elasticity of WTP. This has some important implications. If income elasticity of WTP would increase along with income, the transfers from 'richer' study sites to policy sites lower in income using income elasticity of WTP observed at the policy site would underestimate the expected value of benefits.

We investigated the issue further using the data from our studies. Assuming iso-elastic relationship between WTP and household income in the pooled (Polish and Czech) data, the income elasticity was estimated to be 0.64, what seems comparable with other income elasticity estimates reported above. However, it seems more robust to allow for a more flexible functional form of WTP as a function of income. Specifically, we applied the Box-Cox regression model, allowing for different transformation parameters of the left and right-hand sides of the regression equation as follows:

$$WTP^{(\theta)} = \boldsymbol{\alpha}'\mathbf{z} + \beta income^{(\lambda)}, \tag{5}$$

where $x^{(\alpha)}$ denotes Box-Cox transformation by the parameter α.[14] This general model allows to estimate income elasticity of WTP in the following way:

[14] $x^{(\alpha)} = \begin{cases} \dfrac{x^{\alpha}-1}{\alpha} & \text{for} \quad \alpha \neq 0 \\ \ln x & \text{for} \quad \alpha = 0 \end{cases}$

$$\varepsilon = \frac{\partial \log WTP}{\partial \log income} = \frac{\beta income^{\lambda}}{\theta\left(\boldsymbol{\alpha}'\mathbf{z} + \beta income^{(\lambda)}\right)+1} \tag{6}$$

The maximum likelihood estimates of the transformation parameters were found using the pooled (Polish and Czech) data. However, the parameter λ was not significantly different from 1, leading us to estimate the model in which the only transformation parameter was $\theta = -0.29$ .See Table 2 for the estimation results.

Table 2. Estimation results of Box-Cox models to derive the income elasticity

Parameters:	WTP_1	WTP_1
Intercept (α)	0.32012 (.06691)	.43242 (.07338)
Household income (β)	0.00027 (.00004)	.00032 (.00004)
Theta (θ)	-0.29073 (0.05904)	-.24130 (.05249)
Lambda (λ)	1	1
LogLikelihood	-647.76950	-743.23137

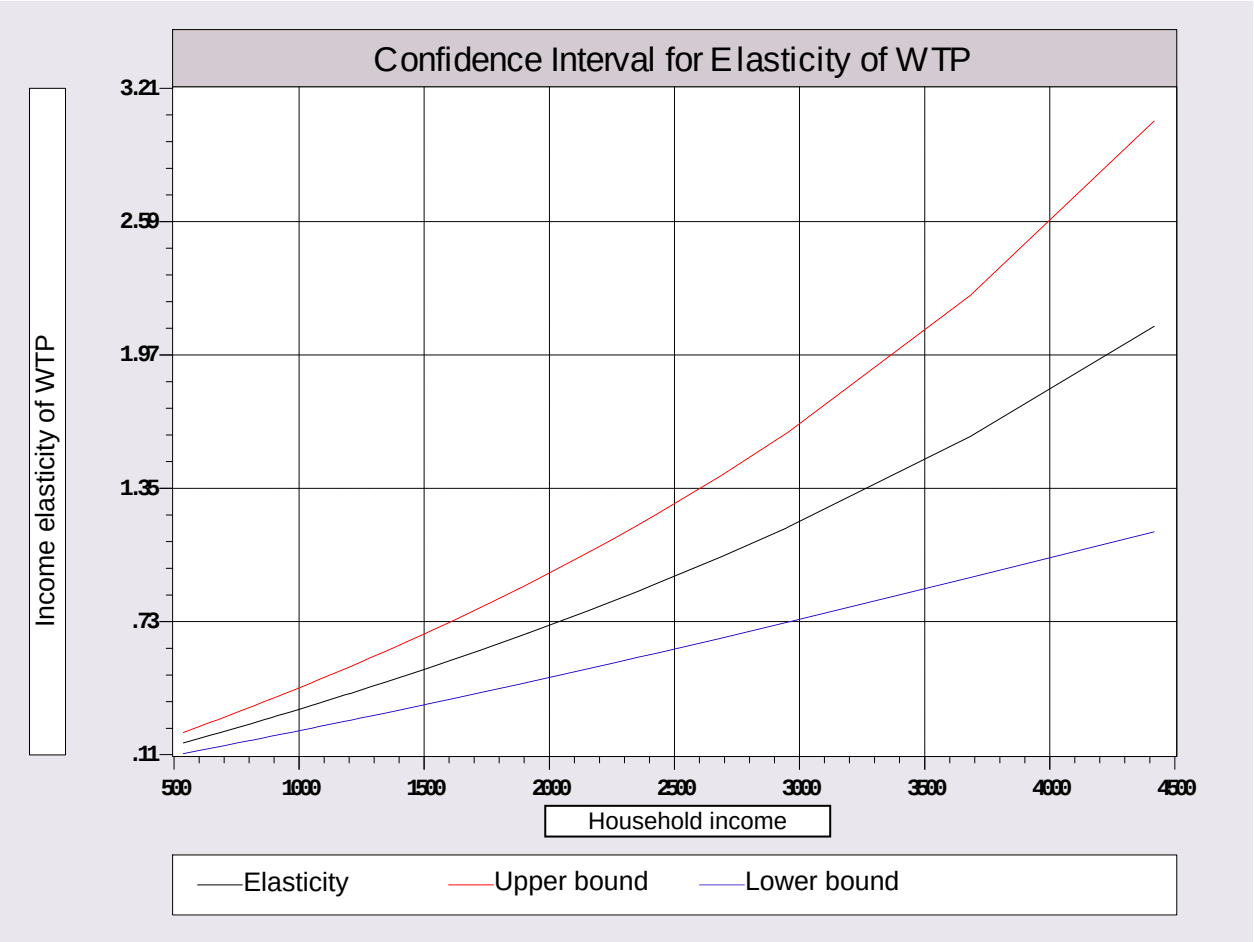
Note: All estimates are significant at less than 1% level

Our results indicate that the income elasticity of WTP is an increasing function of income. Figure 1 illustrates the income elasticity as a function of household income levels reported in the Polish and Czech samples, along with the 95% confidence interval.

The results indicate that WTP would increase faster-than-proportionally with an increase in income in the two transitioning countries. The estimated model suggests that the income elasticity exceeds unity when the income is doubled (after reaching 2940 EUR). It is difficult to speculate how the relationship would behave at the income levels much higher than the currently observed. Forecasting income elasticity pathway trajectory along the significantly higher income levels (such as those observed in Western European countries) requires some arbitrary assumptions, since no data on such income interval is available.

It seems reasonable to expect the income elasticity level returning back to the levels below 1, as currently observed in developed countries. This would suggest the income elasticity function of income to be inverted-U-shaped – increasing as the income levels of transitioning countries increase, but eventually decreasing back to the levels observed in the well developed countries. For this reason, we conclude that for the benefit transfer applications between transitioning and well developed countries it is reasonable to assume income elasticity of WTP equal to 1. After justifying theoretically this approach we turn to analyzing its empirical effects by investigating the performance of benefit transfer with income elasticity (equal to unity) adjustments.

Figure 1: Confidence interval of the income elasticity of WTP in Poland and the Czech Republic



We applied income elasticity adjustment using two alternative indicators on income – a more commonly used (and more easily available) GDP *per capita* and the mean household income observed directly in the primary studies. This proved to introduce significant change in the mean transfer error levels. The average absolute transfer errors resulting from different approaches are summarized in Table 3.

Once the values of the income elasticity are adjusted, the average absolute transfer error is 26%, with 18% between transitioning and developed countries, and 41% between transitioning countries. The average transfer error for GDP *per capita* levels is 88%, while the average transfer error between developed and transitioning countries is 105%, and 55% between transitioning countries. We conclude that adjusting for differences in income proved to substantially improve the accuracy of benefit transfer, especially in the case of transfers between countries highly differentiated in income. In addition, using GDP *per capita* instead average household income at the site proved to control only partially for differences in income – it did not perform as well as using site-specific household income.

Table 3: The mean absolute transfer errors of value transfers (minimum and maximum given in brackets)

	Average	Transitioning *vs.* developed countries	Transitioning *vs.* transitioning countries
No. of observations	**12**	8	4
Market exchange rate	**366% (59 – 1518%)**	495% (80 – 1518%)	108% (59 – 167%)
PPP-corrected exchange rate	**200% (58 – 731%)**	247% (62 – 731%)	104% (58 – 161%)
Transfer with income adjustment (GDP per capita)	**88% (38 – 255%)**	105% (40 – 255%)	55% (38 – 78%)
Transfer with income adjustment (mean household)	**26% (10 – 57%)**	18% (10 – 29%)	41% (30 – 57%)

The valuation studies also allowed for testing the equivalence of the welfare estimates, following Kristofersson and Navrud (2005). However, we argue that specifying an *a priori* acceptable transfer error is highly context-specific and hence less appropriate for general comparisons of benefit transfer performance. Therefore, instead using this approach, we propose to estimate the minimum transfer error that would allow for conclusion on the equivalence of the two values at the 5% significance level. We argue that this new approach is more informative than specifying the error rates only, since it incorporates information about variance and possibly covariance of the two values.

Formalizing, from equation (4) and if the maximum acceptable difference D is expressed as a transfer error following equation (2) the null hypothesis of equivalence test may be rewritten as:

$$H_0 : \left| WTP_{\text{transfered}} - WTP_{\text{observed}} \right| \geq \theta WTP_{\text{observed}} \tag{7}$$

and thus:

$$H_0 : \left| \frac{WTP_{\text{transfered}} - WTP_{\text{observed}}}{WTP_{\text{observed}}} \right| \geq \theta \tag{8}$$

In our approach we applied numerical methods to find the minimum transfer error $\theta_{\min} \in [0, \infty)$ that allows for conclusion that observed and transferred estimates are equivalent at 5% significance level. In other words, we calculate the minimum transfer error $\theta_{\min}$ that allows for rejecting the null hypothesis (8) at 5% significance level, i.e. it satisfies the

observed and transferred estimates are equivalent at 5% significance level. The minimization problem may be specified as:

$$\min \theta \in [0, \infty) \quad \text{s.t.} \quad \Pr\left(\left|WTP_{\text{transfered}} - (1+\theta) WTP_{\text{observed}}\right| \geq 0\right) < 0.05 \tag{9}$$

Setting any policy-specific tolerance level θ lower than $\theta_{\min}$ would allow for conclusion that the estimates are equivalent, at 5% significance level.

In order to test the equivalence of observed and transferred welfare measures we applied the TOSC test (Johnston and Duke 2008). The empirical distributions of each two WTP estimates were obtained using Krinsky and Robb method (Krinsky and Robb 1986) with 10^4 draws. The complete combinatorial convolutions approach (Poe et al. 1994; 2005) was used in order to find the probability of two-sided equivalence of the two values. Our approach allowed for numerically finding the minimum acceptable transfer error for each pair of estimates that would allow for conclusion on their equivalence at 5% significance level. The mean absolute minimum tolerance levels are summarized in Table 4.

Table 4: Mean absolute minimum tolerance levels allowing for equivalence of welfare measures (minimum and maximum given in brackets)

	Average	Transitioning *vs.* developed countries	Transitioning *vs.* transitioning countries
No. of observations	**12**	8	4
Market exchange rate	**250% (50-1031%)**	337% (71-1031%)	75% (50-101%)
PPP-corrected exchange rate	**132% (44-481%)**	162% (44-481%)	73% (49-96%)
Transfer with income adjustment (GDP per capita)	**47% (11-148%)**	56% (11-148%)	29% (25-34%)
Transfer with income adjustment (mean household)	**6% (0-18%)**	0% (0-0%)	17% (15-18%)

The results presented in Table 4 are relatively close to the average absolute transfer errors given in Table 3. However, it must be strongly indicated that the two series of results are different with two respects. First, the results in Table 4 incorporate standard deviations of the estimates, and not their means only; they are thus the more informative. Second, their interpretation is as follows: on average setting the absolute tolerance level lower than specified percentage level allows for a conclusion that the values observed and transferred are equivalent. For instance, when income elasticity approach with household income observed at the site is used, the minimum tolerance level for transfers between developed and transitioning countries is 0%. This indicates that the values are equivalent at 5% significance level, even with 0% tolerance level. This is a result of incorporating standard errors estimated

for each of the welfare measures. The results also indicate that if tolerance levels below 18% are acceptable, all the transfers between the two transitioning countries are equivalent, when income elasticity approach with site-specific data is used.

These results are specific to the studies in our sample. However, they allow for relative optimism about the validity of the international benefit transfer. The mean tolerance levels are relatively low, and hence may be seen as encouragement for employing benefit transfer in applications where the higher tolerance levels are accepted.

Finally, it is noteworthy that the function transfer approach was also applied. However, this method did not perform better than value transfer with appropriate corrections. This was probably the result of the fact that the most explanatory socio-demographic variables were not found significant at all sites simultaneously. Since the function transfer may be expected to perform well only in case of dissimilarities of the sites which are possible to control with a set of explanatory variables, the relative better performance of value transfer does not come as a surprise.[15]

6. Discussion and Conclusions

Our study aims to improve the benefit transfer methods by providing guidelines to increase performance of these methods in case of the countries' income heterogeneity. This is achieved by conducting four studies that applied virtually the same setting and questionnaire in one developed and two transitioning countries in order to make sure that survey artefacts do not bias the welfare estimates.

Our results allow for relative optimism. Even in the case of high differences in income between the countries, the transfer errors and minimum tolerance levels may be brought down to the levels which seem acceptable in many policy applications. This can be achieved by controlling for the differences, especially with regard to income. Our study demonstrates how efficient these methods can be and provide encouraging evidence for the future benefit transfers.

Controlling for differences in price levels proved to be vital and it should be the first step for benefit transfers. We demonstrate that using PPP-corrected exchange rates, instead of market exchange rates, can substantially increase performance of benefit transfer. This improvement is relevant particularly for transfers between transitioning and developed countries, where this alone allows for a 50% decrease in mean transfer errors (495% to 247%) and minimum tolerance levels (337% to 162%). The gain in accuracy for transfers between two countries with similar income levels is less stark. Therefore, the differences in price levels between countries highly differentiated in income constitute an important factor for differences in welfare estimates.

However, even after controlling for differences in price levels the transfer errors and minimum tolerance levels of transfers between countries differentiated in income are much

[15] For more detailed result of function transfer see (Czajkowski et al. 2006).

higher than transfers between similar countries. This indicates that not all the differences have been fully controlled for. To account for that we utilized the income elasticity approach. The evidence from our data shows that controlling for income heterogeneity is crucial. Using the mean household income of the region of study may substantially reduce both the transfer errors and the minimum tolerance levels. This relationship is especially visible for transfers between countries different in income levels – the mean transfer error is reduced by over 90% (mean transfer error reduced from 247% to 18%), and the same holds for reduction in minimum tolerance levels (162% to 0%).

We argue that the best practice for controlling income heterogeneity is assuming income elasticity of WTP equal to 1. This might seem a somewhat arbitrary assumption however there are at least two reasons for it. First, using income elasticity of WTP observed only at a policy or a study site is not convincing. This is because income levels observed at policy and study sites need not overlap and in case of transfers between developed and transitioning or developing countries they would be highly apart. Secondly, there is growing body of research demonstrating that income elasticity of WTP needs not be constant. Our results show that the income elasticity in an increasing function of income, and it may well exceed 1 for the higher quantiles of income. The efficiency of using income elasticity equal to 1 is supported by relative performance of benefit transfer following this simple approach. Thus, our study provides theoretical background and empirical evidence for this method. For these reasons we suggest using income elasticity equal to 1 for future benefit transfer applications, especially with strong income heterogeneity of the countries.

Since site-specific income data might not be readily available for some applications, we have also investigated the possibility to use *per capita* GDP of the country, as a proxy for income. Our results demonstrate that even though this approach improves performance of benefit transfer, the scope of the increase is not as substantial. This result is not in line with e.g. Jacobsen and Hanley (forthcoming), who observe that household income observed within the sample and *per capita* GDP perform equally well. However, we suggest using *per capita* GDP as a proxy of income only as a second-best option. Due to our evidence, we encourage researchers to derive income from the region as close to study site as possible; our results demonstrate the potential gains in performance when site-specific income data is used.

Our study adds to the discussion of relative performance of value transfer *vs.* function transfer. We demonstrate that the function transfer, believed to perform better in a dissimilar contexts (Chattopadhyay 2003; Brouwer and Bateman 2005), does not necessarily do so. This finding is in line with the results of e.g. Barton (2002), Ready et al. (2004), Ready and Navrud (2006) and Brouwer (2000). In our case most of explanatory variables were not significant at the study and policy sites simultaneously, what caused transfer errors to be comparable to those of value transfers or higher.

Finally, we based our conclusions on equivalence tests of welfare estimates (Kristofersson and Navrud 2005) using a relatively new construct of the TOSC test (Johnston and Duke 2008). This approach allows for incorporation of the standard errors of welfare estimates into comparisons, and is thus a more informative. However, instead setting an *a priori* tolerance level (which is highly specific to a particular policy application), we propose a more

computationally intensive, but revealing more information technique of reporting minimum tolerance level, which allows for the two estimates to be equivalent at 5% significance level. We argue that this approach is more useful for comparing relative performance of benefit transfer protocols, since it provides information about minimum tolerance levels which would allow the transferred welfare estimates to be valid.

In conclusion, our findings provide support and guidance for future applications, with a particular focus on transfers between countries heterogeneous in income. By seeking for differences between the studies and finding efficient ways of controlling for them, we propose scientifically sound ways to improve the performance of benefit transfer, and demonstrate its relative improvement based on 42 benefit transfer exercises. Overall, our findings are encouraging – controlling for the most vital differences allows for shifting the transfer error and the minimum tolerance to a level acceptable for many policy applications. This seems to be a valuable result especially for benefit transfers between countries highly heterogeneous in the levels of income.

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Faculty of Economic Sciences
University of Warsaw
44/50 Długa St.
00-241 Warsaw
www.wne.uw.edu.pl