

Internal Migration, Environmental Amenities
and Life Satisfaction: Theoretical Linkages, Empirical
Evidence and Methodological Advances

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Introduction

The fundamental question of how to measure well-being is being revitalized in public debate today. This results from skepticism towards the suitability of the gross domestic product (GDP) to provide information about a country's ability to convert growth into well-being, which has been raised since the early 1970's (see Nordhaus and Tobin, 1972). In 2009, the Stiglitz-Sen-Fitoussi-Commission, a group of experts appointed by the French government, presented a landmark report on the measurement of economic performance and social progress. It summarizes the limits of GDP such as taking no account of distribution, sustainability or well-being enhancing activities taking place outside the market such as caring of the elderly and sick (see Stiglitz et al., 2009). On the basis of these observations, the commission identifies indicators that could complement GDP and advises "to shift emphasis from measuring economic production to measuring people's well-being" (Stiglitz et al., 2009: 12).

The development of indicators to measure people's well-being requires insights from applied research studies that use various methods from the economic and other social sciences. According to the commission, one of these methods is the empirical life satisfaction approach, analyzing people's subjective well-being using cognitive evaluations of one's life (see Stiglitz et al., 2009). It has its roots in psychology and has been widely applied in sociological and lately also in economic literature. According to this approach, life satisfaction is estimated as a function of factors such as income, education and environmental amenities etc., providing policy relevant information on the factors that determine well-being (see Stutzer and Frey, 2010).

Apart from contributing to the development of measures for people's well-being, another important policy contribution of the life satisfaction approach is the provisioning of economic values for public goods such as environmental amenities, which are part of the empirical life satisfaction function (see Welsch and Ferreira, 2014). Government agencies more and more frequently call for such information as an input to cost-benefit analyses that they need for backing up their proposals for government programs. However, the benefits derived from many public goods are difficult to measure, especially from environmental amenities that are often not traded on markets, as objective information on prices is not available (see Stutzer and Frey, 2010).

In the earlier environmental economics literature, other methods have been developed including stated preferences methods, such as contingent valuation or choice modeling, (see

Mendelsohn and Olmstead, 2009 for a review) and revealed preferences methods such as hedonic pricing (see Waltert and Schläpfer 2010, for a review). Only recently, the empirical life satisfaction approach has been added to the variety of methods for valuing environmental amenities.

According to the empirical life satisfaction approach, a monetary measure for benefits from changes in environmental amenities is derived from the estimated life satisfaction function. It is based on the marginal rate of substitution (MRS) between income and the environmental amenity (determined by the quotient of the coefficient of the environmental amenity in question and the income coefficient) (see Welsch and Ferreira, 2014). Environmental amenities that have been valued in the literature in this way include air quality (see e.g. Luechinger, 2009 or Menz and Welsch, 2012), aircraft noise (see e.g. Van Praag and Baarsma, 2005), climate (see e.g. Rehdanz and Maddison, 2005) and land cover (see e.g. Kopmann and Rehdanz, 2013 or MacKerron and Mourato, 2013). Welsch and Ferreira (2014) provide a comprehensive overview.

Based on selected issues, this dissertation is designed to provide new insights from the application of the life satisfaction approach to valuing regional and environmental amenities and to enhance the provisioning of policy implications by presenting methodological advances for this approach.

1. Selected Issues

The dissertation is divided into two parts. Part 1 links empirical life-satisfaction analyses on internal migration to economic theory and assesses benefits deriving from changes in regional and environmental amenities using cross-section and panel data for Europe and for Germany, respectively. Part 2 proposes methodological advances with respect to the measurement of the effect of income on life satisfaction using panel data for Germany. More specifically, I set out to answer the following questions:

Part I: Theoretical linkages and empirical evidence

Paper 1: How can life-satisfaction analyses on internal migration be linked to economic theory? How does the existing literature succeed or fail to correctly attribute changes in life satisfaction due to migration to benefits from regional amenities as suggested by economic theory? What is the size of benefits deriving from changes in regional amenities in terms of household income?

Paper 2: Taking natural land cover as one example, how do environmental amenities affect the level of life satisfaction? What does the ordering of benefits deriving from changes in natural land cover imply?

Paper 3: Do people benefit in terms of their life satisfaction from moving to the green? How successful is the existing literature in correctly estimating benefits from green land cover? What is the relative importance of benefits deriving from changes in green land cover in terms of household income?

Part II: Methodological advances

Paper 4: What can we learn from Friedman's permanent income-hypothesis for uncovering causal effects of income on life satisfaction? Does income information generated from matching households based on their investment decisions provide a reasonable instrument for household income? How do findings from this instrumentation strategy relate to findings in the literature?

In Part 1, the first contribution to the existing literature is linking empirical life-satisfaction analyses on internal migration to economic theory. The second contribution is to reassess empirical findings of the effects from internal migration on life satisfaction. Insights from these contributions are used for estimating benefits deriving from changes in regional amenities due to migration. Third, I add to existing research by discussing the limitations of previous life satisfaction studies on benefits from changes in natural or green land cover. Fourth, I add to the existing literature by overcoming these limitations when estimating benefits deriving from changes in green land cover. In Part 2, I add to existing research by discussing the limitations of instruments developed in the earlier life satisfaction literature and presenting a new instrument for income. Providing a new instrument for income contributes to the accuracy in the estimation of monetary measures for environmental amenities.

2. Overview and Results

The four papers of my dissertation follow the issues referred to above. The first three papers focus on theoretical linkages between empirical life satisfaction analyses and economic theory and on the estimation of benefits from regional amenities and environmental amenities. In the first paper, *Estimating Benefits from Regional Amenities: Internal Migration and Life*

Satisfaction (Faßhauer and Rehdanz, 2015)¹, my co-author and I derive an empirical life-satisfaction model of internal migration from an extension of the Roback (1982) model that accounts (among other things) for regional amenities. Using highly disaggregated spatial panel information on people's migration decisions and their life satisfaction taken from the German Socio-Economic Panel (GSOEP) for the years 2006-2010, we use an individual fixed-effects model to rule out selection bias, while accounting for endogeneity of income and reassess empirical findings.

Unlike earlier empirical studies on internal migration, we apply weighted estimators to adjust for differences in the sampling design over and against the true population. We show that this substantially changes results: life satisfaction remains insignificantly different from zero the years before migration and shifts upward significantly after the migration event. In line with economic theory, this pattern would be compatible with the hypothesis of migration providing benefits deriving from changes in regional amenities when other factors related to the decision to migrate are controlled for. Monetary measures derived from empirical findings indicate that benefits from changes in regional amenities due to migration are equivalent to 21 percent of household income.

In the second and third paper, different perspectives are used to estimate effects deriving from changes in green (or natural) land cover on life satisfaction. In the second paper, *A human well-being approach for estimating benefits from natural land cover* (Kopmann and Rehdanz, 2013)², my co-author and I use a cross-sectional perspective to determine the level effect of natural land cover on life satisfaction, paying special attention to non-linearities in household preferences. The analysis is based on data from the European Quality of Life Survey (EQLS) from the year 2007, which provides information on 31 European countries up to the NUTS 2 level, and CORINE land cover data for the year 2006. We analyze effects of land cover on life satisfaction for European countries and for four sub-regions to test whether preferences for land cover differ by region.

We find that natural land cover has an effect on life satisfaction for people living in Europe, regardless of the region. According to model-selection measures, a nonlinear

¹ An earlier version of this paper was published as Faßhauer, A. and K. Rehdanz. 2015. Estimating Benefits from Regional Amenities: Internal Migration and Life Satisfaction. SOEPpaper No. 748. Available at: http://www.diw.de/documents/publikationen/73/diw_01.c.504259.de/diw_sp0748.pdf. This paper was written jointly with Katrin Rehdanz, who supported me in developing the conceptual design of the analysis. The link between the theoretical and empirical model was designed and written by me. I performed the analysis and wrote most of the paper. Both co-authors contributed substantially to rewriting and polishing the paper.

² This paper was written jointly with Katrin Rehdanz. We agreed on the idea and the conceptual design of the analysis. Implementation of the concept into a program code was mostly done by me. Both co-authors contributed substantially to writing the paper.

relationship between land cover and life satisfaction is preferred to a linear relationship, indicating decreasing benefits from individual landscape amenities. Based on estimation results, we derive monetary estimates for benefits deriving from changes in land cover. We find that the ordering of benefits from natural land cover is partly driven by the scarcity of the land cover categories. In other words, monetary values tend to be higher (lower) for those land-cover categories with the lowest (highest) shares, indicating preferences for “balanced” over “extreme” allocations of land cover.

In the third paper, *Moving to the Green* (Faßhauer, 2015), I use a longitudinal perspective to determine the effect of changes in green land cover on life satisfaction. The analysis is based on panel data from the GSOEP for the years 2006, 2008, and 2010, which is restricted by availability of land cover data. I use land cover data provided by the Leibniz Institute of Ecological Urban and Regional Development (IOER). To avoid omitted variable bias, I control for other environmental characteristics conceivably correlated with a green living environment and also affecting life satisfaction.

I find that moving to a greener living environment increases life satisfaction. Based on estimation results, I derive monetary measures for benefits deriving from changes in green land cover. The benefits from moving to a living environment featuring an increase of 1 km² of water area and urban green area (forest area and agricultural area) are largest (lowest), representing 28 percent and 13 percent (1 percent for both) of household income, respectively. These results suggest that benefits from changes in green land cover depend entirely on scarcity of land-cover types.

I compare my findings to earlier findings in the literature (including findings presented in the third paper). I conclude that the estimated effects from changes in natural land cover on life satisfaction in cross-section analyses might be subject to selection bias, as individual fixed effects cannot be applied. My findings also suggest that focusing on the living environment corrects for upward bias in estimates for specific land-cover categories such as marine and coastal margins or mountain, heathland, and moors that might result from vacationing.

The fourth paper, *Uncovering Causal Effects of Income on Life Satisfaction using Permanent Income Expectations* (Faßhauer and Vendrik, 2015)³, provides methodological advances in empirical life satisfaction analyses related to the estimation of the income effect. My co-author and I present a new instrumentation strategy for income derived from

³ This paper was written jointly with Maarten C. M. Vendrik. I came up with the original idea for the paper. We agreed on the conceptual design of the analysis. I implemented the concept into program code and wrote the paper. Both co-authors contributed substantially to rewriting and polishing the paper.

Friedman's concept of permanent income and matches households based on their investment decisions. The instrument is applied to an empirical life-satisfaction model in Error-Correction form, which jointly considers adaptation and social-interaction effects of income. For our empirical analysis, we use data from the GSOEP for the years 1984-2010.

We find that when measurement error of income is accounted for by instrumenting income with matched income from households with similar investment decisions, the income effect is increased by a factor of 4. We show that this yields a correction of the income effect that is slightly above findings from instrumenting income with predicted labor income, another instrument presented in the literature (see Luechinger, 2009 or Vendrik, 2013). Further findings indicate that our instrument is appropriate, as it passes standard exogeneity tests. In contrast to predicted labor earnings, our instrument has the advantage of being applicable to a broader sample including individuals not in the labor force and older people. Implications of our findings are that monetary estimates for benefits deriving from changes in environmental amenities are scaled by a factor of 0.25 when measurement error of income is accounted for.

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Part I: Theoretical Linkages and Empirical Evidence

Paper 1:
Estimating Benefits from Regional Amenities:
Internal Migration and Life Satisfaction*

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Abstract

We link economic theory with life-satisfaction analyses referring to internal migration and reassess earlier empirical findings. We derive the empirical life satisfaction model from an extension of the Roback (1982) model that accounts for benefits from regional amenities in the utility function, while controlling for income, housing costs, and migration costs. Using highly disaggregated spatial panel information on people's migration decisions and their life satisfaction for Germany, we use an individual fixed-effects model to rule out selection bias, while accounting for endogeneity of income. Unlike earlier empirical studies on internal migration, we apply weighted estimators to adjust for differences in the sampling design over and against the true population. We show that this substantially changes empirical findings: life satisfaction remains insignificantly different from zero the years before migration and shifts upward significantly after the migration event. In line with economic theory, these positive effects approximate benefits from regional amenities; they represent about 21 percent of household income.

Keywords: internal migration, regional amenities, life satisfaction, Germany.

JEL codes: A12, D6, I31, R23

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1. Introduction

Economic theory suggests that individuals will migrate if the benefits from migration are high enough to cover the associated costs. In a seminal paper, Roback (1982) shows that migration is determined by an equilibrium state of market rents and wages. Higher levels of regional amenities, such as climate or proximity to the coast, are offset by lower levels of wages or higher levels of rents (or both), and utility is equalized over space. Bayer et al. (2009) have proposed the residential sorting model as an extension of the Roback model. It additionally accounts for migration costs in the utility function, modeling location choices to reveal benefits from regional amenities.

An alternative approach that suggests itself for measuring benefits from regional amenities is the life satisfaction approach where recently first advances have been made in basing the approach on economic fundamentals (see Welsch and Ferreira, 2014). These advances are so far limited, however, when it comes to internal, i.e. within-country, migration. Previous empirical life satisfaction studies on internal migration were, due to data restrictions, unable to separate the migration effect into benefits from regional amenities and other factors as suggested by economic theory (see e.g. Nowok et al., 2013 or Switek, 2012). However, regional amenities have been found to be important determinants of migration next to economic characteristics in quality of life studies (see Rappaport, 2007 or Porell, 1982). The omission of such factors from empirical models has been recognized as one major limitation of early migration studies (see Greenwood, 1997).

The aim of this paper is to link economic theory with life-satisfaction analyses referring to internal migration and reassess empirical findings. More specifically, we extend the previous literature in two ways. First, in a theoretical section, we extend the Roback (1982) model to derive an indirect utility function that accounts for benefits from regional amenities alongside income, housing costs, and migration costs. Second, in our empirical section we directly estimate this indirect utility function, using life satisfaction as a proxy for experienced utility. Unlike earlier empirical studies on internal migration (see Nowok et al., 2013), we make use of panel weights. We show that this substantially changes empirical results: life satisfaction remains insignificantly different from zero the years before migration and shifts upward significantly after the migration event. In line with economic theory, this pattern would be compatible with the hypothesis of migration providing benefits deriving from changes in regional amenities when other factors that are related to the decision to migrate are controlled for (further individual characteristics, housing characteristics, social ties, and regional

economic characteristics). The ultimate goal of our empirical analysis is to provide a monetary measure for these benefits deriving from changes in regional amenities.

In this article, we take advantage of one of the assets of the German Socio-Economic Panel (GSOEP), i.e. that of providing regional information on the residences of households at the municipality level, which is the lowest level of official territorial division in Germany.¹ By presenting evidence from a large representative panel dataset, we address several concerns that are common in connection with cross-sectional data. When focusing on regional amenities, selection bias arises if individuals with specific characteristics are selected into regions with higher (lower) levels of regional amenities. Assume, for example, that extrovert people are more satisfied and tend to be more prone to migration, improving their situation by migrating to regions with higher levels of regional amenities. This causes an overestimation of benefits from regional amenities in regions with higher amenity levels (and, similarly, an underestimation in regions with lower amenity levels). The use of panel data providing repeated observations of individuals over time enables us to overcome potential selection bias by controlling for time-invariant individual fixed effects in the empirical analysis.

We begin the analysis by approximating benefits deriving from changes in regional amenities for the working age population, while controlling for income, housing costs, migration costs, and other socio-economic characteristics. In the next stage, we test whether our findings are robust to various sources of bias from omitted variables, such as housing characteristics, social ties, and regional economic characteristics. The final step is then to derive from the empirical model a conservative monetary measure for the trade-off between income and benefits from changes in regional amenities. Here we instrument income with predicted labor earnings in the wake of Luechinger (2009) and Vendrik (2013).

Our main findings indicate that benefits from changes in regional amenities due to migration are equivalent to 21 percent of household income. These benefits from regional amenities are much larger than migration-related income gains, which represent only 3 percent of household income. However, these benefits also involve costs that partly mitigate their effect. Housing costs measure 3 percent of household income. Migration costs represent 1.5 percent of household income, but in statistical terms, they do not differ significantly from zero.

The paper is structured as follows: In Section 2 we present an overview of previous research. In Section 3 we provide information on the theoretical background and the empirical

¹ The average size of municipalities in our sample is 63 km².

specification. The data set is described in Section 4. In Section 5 we present our empirical findings. Robustness results are discussed in Section 6. In Section 7 we monetize benefits from regional amenities. Our conclusions are presented in Section 8.

2. Previous Research

2.1 Studies based on the hedonic model and the residential sorting model

Previous empirical studies aiming to determine benefits from regional amenities are either based on Roback's (1982) hedonic model or, more recently, on residential sorting models (see Bayer et al. 2009). In hedonic studies, the coefficient obtained by regressing wages or house prices on regional amenities can be used to calculate the marginal willingness-to-pay (MWTP) for changes in regional amenities. Regional amenities that have been valued in the literature in this way include air quality and open space. Applying house price regressions for large U.S. cities, Zabel and Kiel (2000) find a negative MWTP for a one-unit increase in the concentration of particulate matter, indicating air pollution as being a disamenity. Using house price regressions for central Maryland, Irwin (2002) finds a positive MWTP for permanently preserved open space relative to developable agricultural land and forests. For a summary, see Waltert and Schläpfer (2010). However, the Roback model rests upon assumptions that do not necessarily hold, thus causing potential bias in the estimates. The first of these is that migration equalizes utility (market equilibrium), the second that migration is costless (see Mäler, 1977).

To offset the latter limitation, Bayer et al. (2009) propose the use of a residential sorting model. This extends the Roback model by explicitly accounting for migration costs in the utility function. The residential sorting model provides MWTP estimates for changes in regional amenities by estimating a discrete choice model for the probability that individuals will locate in a specific region. Similarly to Zabel and Kiel (2000), Bayer et al. (2009) find negative MWTP estimates for ambient concentrations of particulate matter when applying the residential sorting model. They also find that estimates are 3.5 times larger from the residential sorting model with migration costs than from hedonic regression without migration costs. Application of the residential sorting model is however limited. Klaiber and Phaneuf (2010) find that the MWTP for an increase of non-park open space is higher (lower) for households with higher (lower) income. Sinha and Cropper (2013) find a positive MWTP for higher winter temperatures and a negative MWTP for higher summer temperatures.

2.2 Life satisfaction analyses and internal migration

The hedonic model and the residential sorting model make no use of the indirect utility function as such. The approach we present estimates the indirect utility function by using life satisfaction as a proxy for experienced utility. Several earlier studies have focused on validation tests for life satisfaction as a proxy for experienced utility. It transpires that life-satisfaction scores are correlated with other variables associated with true individual well-being (see Frey and Stutzer, 2002), which supports the validity of life satisfaction as a proxy for experienced utility. To overcome possible limitations related to interpersonal comparison, an increasing number of studies analyze intrapersonal changes in life satisfaction by using individual panel information.

Life-satisfaction studies have focused on individual benefits of household income, leisure activities, individual costs of commuting, physical and mental health, and environmental amenities and disamenities (see Welsch and Ferreira, 2014, for a recent review of the literature). Only very few of them explicitly link life satisfaction with internal migration. Switek (2012) finds positive short-term effects on life satisfaction from internal migration within Sweden. These effects are driven by housing satisfaction for non-work-migrants and improvements in occupational position for work-migrants.

Empirical findings by Nowok et al. (2013) do not suggest any long-term effects from internal migration for the UK. Instead, significant declines in life satisfaction in the four years before migration are offset by increases in life satisfaction from migration, with people re-attaining their initial levels throughout the five years following migration. This pattern would be compatible with the hypothesis of migration taking place as a result of some stressor. It suggests that migration does not improve life satisfaction relative to the migrant's status before the stressor took effect. Findings by Nowok et al. (2013) also suggest that despite the higher social and psychological costs involved, the level of life satisfaction for long-distance migrants (≥ 25 km) is at least as high as the level of life satisfaction for short-distance migrants (< 25 km).

Studies analyzing internal migration decisions for Germany are based on information concerning East-West migration subsequent to German reunification in 1990. These studies suggest that significant increases in life satisfaction in the years after migration apply to permanent East-West migrants only (see Fuchs-Schündeln and Schündeln, 2009).

Existing life-satisfaction studies on internal migration are limited in two ways. First, they are based on unweighted estimators, which is why their findings are not necessarily representative. Second, they are unable to control for important factors such as housing costs or migration costs, providing instead aggregate effects of internal migration. Third, they focus on migration between aggregated regions. In the case of Germany, for example, they only differentiate between East and West when focusing on migration decisions linked to German reunification (see Fuchs-Schündeln and Schündeln, 2009).

3. Theory and Empirical Specification

3.1 Utility maximization and regional amenities

Following Roback (1982), we assume that each individual i in region j maximizes utility subject to a budget constraint by choosing the quantity of consumption of a numeraire good C and units of housing H . The level of region-specific regional amenities is given by A . Following Bayer et al. (2009), we extend the Roback model by considering migration costs MC . These are independent of location, i.e. they capture social and psychological costs and do not appear in the budget constraint. Finally, individuals have identical preferences.

The utility function is given as follows:

$$U = f(C, H, A, MC), \quad (1)$$

where U reflects the level of utility.

An individual maximizes utility given the following budget constraint:

$$Y - C - RH = 0, \quad (2)$$

where R represents housing costs per unit of housing. Substituting optimal values of consumption and housing, we obtain the following indirect utility function:²

$$V(Y, R, A, MC) = k, \quad (3)$$

where k is the common level of utility. The level of amenities in a region shifts the indirect utility function V upwards or downwards, depending on whether it is an amenity (benefits) or disamenity (costs). Migration costs shift the indirect utility function downwards.

According to this view, migration takes place as a result of equating the benefits and costs of migration. Any region with a higher level of regional amenities will experience in-

² See Appendix A.1 for the derivation.

migration until, in some combination, income Y falls or housing costs per unit of housing R rise sufficiently to eliminate the utility differential (see Greenwood, 1997). The net impact of changes in the level of amenities is then zero:

$$\frac{dV}{dA} = \frac{\delta V}{\delta A} + \frac{\delta V}{\delta Y} \frac{dY}{dA} + \frac{\delta V}{\delta R} \frac{dR}{dA} + \frac{\delta V}{\delta MC} \frac{dMC}{dA} = 0. \quad (4)$$

As shown in equation (4), the marginal utility from regional amenities $\delta V/\delta A$ is offset by marginal net disutility from changes in income $\delta V/\delta Y dY/dA$, housing costs $\delta V/\delta R dR/dA$, and migration costs $\delta V/\delta MC dMC/dA$ in equilibrium.

3.2 Empirical specification

Taking advantage of the panel structure of our dataset, we control for various sources of omitted variable bias using individual fixed effects. In analyzing benefits from regional amenities, one major concern is selection bias. This occurs because people select themselves into regions with higher (lower) levels of regional amenities depending on their individual characteristics. For example, extrovert people tend to be more satisfied with their lives, while at the same time tending to be more prone to migration, feeling that they can improve their situation by migrating to regions with higher levels of regional amenities. In cross-section analyses, the benefits from changes in regional amenities are then overestimated in regions with higher levels of regional amenities (and underestimated in regions with lower levels of amenities). If panel information is available, the individual fixed-effects approach can partly overcome this limitation. In addition to observable time-varying characteristics explicitly considered in the analysis, such as age or health, the approach enables researchers to control for time-invariant individual characteristics such as personality traits. To control for policy shocks that affect all individuals similarly and may also affect an individual's decision to migrate (such as the financial crisis, which increases the probability of job-related migration decisions), we include year-fixed effects.

Taking these controls into account and assuming a Cobb-Douglas utility function (see Appendix A.1 for a derivation) for measuring indirect utility V in equation (3), we derive our empirical life satisfaction model. In order to capture the time path of life satisfaction relative to the time of migration, we use a series of dummy duration variables. They present the number of years before or after the occurrence of a migration event. We reassess earlier empirical findings estimating *an unweighted and a weighted version* of the dynamic model as follows:

$$LS_{i,j,t} = \beta_y \ln Y_{i,t} + \beta_x X_{i,t} - \beta_h \ln R_{i,j,t} + \sum_{s=-T_1}^{T_2} \beta_{a,s} A_{i,s,t} + \beta_d D_{i,t} + \mu_t + v_i + \varepsilon_{i,j,t}, \quad (5)$$

where $LS_{i,j,t} = \ln(\exp(LS_{i,j,t})) = \ln V$, which represents reported life satisfaction of individual i in region j at time t .³ $X_{i,t}$ are socio-economic characteristics of individual i at time t detailed below. Migration costs MC are given by $\beta_d D_{i,t}$, where the coefficient β_d reflects the marginal costs of migration distance and $D_{i,t}$ is the migration distance for individual i at time t . We assume that migration costs MC are only greater than zero for migrants in the period of migration; otherwise they are zero. The variables $A_{i,s,t}$ are migration dummies taking the value of one if an individual i migrates in period $t-s$, with s indexing the variables beginning T_1 years before and ending T_2 years after migration, and zero otherwise. For instance, $A_{i,2,t} = 1$ if an individual migrated two years before the year t . At time t , the individual has been living in a new place of residence for two years. If $A_{i,-2,t} = 1$, then the individual will migrate to a new place of residence in two years. The coefficients of the migration dummies $\beta_{a,s}$ measure the migration effect prior to ($s \leq -1$) and following the migration event ($s \geq 0$). Finally, μ_t are year-fixed effects, v_i are individual fixed effects, $\varepsilon_{i,j,t}$ is the error term, and $\beta_y, \beta_x, \beta_h$ are further coefficients to be estimated.

In a second step, we specify our *baseline model*. To rule out omitted-variable bias, we control for further characteristics (further individual characteristics, housing costs and migration costs). The introduction of further controls reduces our sample size and the number of migrants in particular in the years before and after the migration event. Therefore, we use a version of the model that only accounts for the migration dummy at time zero ($A_{i,0,t}$). The omission of the migration dummies prior to and following the migration event tends to bias the migration effect downwards. However, this model is suitable for approximating the migration effect, since we are more concerned with overestimating benefits from migration.

In *extensions of the baseline model*, we add further controls that are not standard in life-satisfaction analyses, but which might simultaneously influence the dependent variable (life satisfaction) and the decision to migrate, thus causing potential bias in the effect of migration on life satisfaction. Additional controls that we consider are housing and neighborhood characteristics (first extension), social ties (second extension), and regional economic characteristics (third extension).

So far, the thing that all model specifications have in common is that endogeneity of income may bias the income coefficient downwards. A downward bias in the income

³ Life satisfaction is left skewed. As is standard in the literature, we assume an exponential transformation of this variable to obtain a normal distribution.

coefficient is of major concern in our analysis as it causes an upward bias in the trade-off between income and the migration effect, which provides a monetary estimate for benefits from regional amenities (see Section 7). Potential sources of downward bias in the income coefficient are individual efforts leading to higher earnings and positively affecting life satisfaction (see Luechinger, 2009) or measurement errors in income (see Vendrik, 2013). To correct for downward bias in the income coefficient, we follow Luttmer (2005), Luechinger (2009), and Vendrik (2013) and use predicted labor earnings as an instrument in the fourth and final extension of the baseline model.

3.3 Estimation method

Two methods can be applied to estimate the above models. First, ordered logit can be used to account for a non-linear relationship or ordinality in the dependent variable. However, this requires averaging the marginal effects to calculate the effects on life satisfaction, which is open to criticism. Second, Ordinary Least Squares (OLS) can be applied when error terms are adjusted for heteroscedasticity, which may be less accurate due to the cardinality assumption. Ferrer-i-Carbonell and Frijters (2004) have shown that controlling for individual fixed effects is much more important than assuming ordinality or cardinality of the dependent variable in life-satisfaction analyses. In our analysis, we use OLS to estimate the model for greater ease of interpretation and apply (ordered) logit for a robustness check. As expected, the results are not affected.

Estimating an empirical life-satisfaction model with individual panel information at the regional level raises two issues. First, observations may be correlated across individuals over time, and/or second, observations may be correlated within regions as people living in the same region tend to be more similar than they would be otherwise. It is important to cluster standard errors at the appropriate level, as this relaxes the assumption that observations are independent and adjusts standard errors for intra-personal and/or intra-regional correlation accordingly (see Moulton, 1990). Estimating the model without clustering at the appropriate level yields standard errors that are too small, thus too often suggesting a rejection of the null. To overcome this issue, we tested for clustering of errors at the individual level i and at the regional level j . Results show that clustering at the individual level yields more conservative inferences of migration effects than clustering at the regional level or two-way clustering at both the individual and the regional level. This is why we cluster at the individual level throughout the paper.

We weight regressions with panel sampling weights provided by the GSOEP to adjust for differences in the sampling design over and against the true population. The weights are a multiplicative combination of the inverse of the probability of observing individuals and the inverse of the staying probabilities (see Kroh, 2012). In addition, disparities in the distribution of chosen characteristics like age, gender, district magnitude, etc. are adjusted by poststratification (see Kroh, 2009).

4. Data

Our analysis is based on data taken from the German Socio-Economic Panel (GSOEP) for five consecutive years (2006 to 2010). The Panel is a representative longitudinal study providing socio-economic information on approximately 20,000 individuals and 10,000 households in Germany (see Wagner et al., 2007). We restrict our sample to those aged between 18 and 63, the latter representing the average retirement age in Germany in 2006 (DRV, 2012).⁴ In the GSOEP, information on life satisfaction (our dependent variable) is obtained by asking individuals the following question: “*All things considered, how satisfied would you say you are with your life these days?*” Respondents can choose from an ordinal scale of 0 to 10, where 0 stands for very dissatisfied and 10 for very satisfied.

We investigate migration at the lowest level of official territorial division in Germany, the municipality level.⁵ We classify those individuals that move across administrative borders of municipalities as migrants. Since on average the area of a municipality is small, we assume that (for ‘within’ municipality movers) regional amenities, the social, and the working environment do not change. However, we add a dummy variable for moving ‘within’ municipalities to control for any such effects. In our sample, the share of migrants is 5.8 % per year on average (which equals 555 migrants). This is very close to figures from the Federal Statistical Office of Germany (*Statistisches Bundesamt*) according to which 5.4 % of Germans moved across the administrative borders of municipalities in 2006.⁶ Our final sample consists of 43,941 observations (or 9,562 persons) and 8,745 municipality-year combinations (or 1,746 municipalities).

⁴ In our analysis below, early retirees are classified as ‘non-working’.

⁵ There were more than 12,000 municipalities in Germany with an average size of 29 km² in 2006 (*Statistisches Bundesamt*). Since their number changes over the sample period, we distinguish 11,449 regions. Data can be accessed at: www.destatis.de.

⁶ Own calculations based on information from the Federal Statistical Office (*Statistisches Bundesamt*) for 2006; share of ‘within’ migrants (excluding immigrants from other countries) compared to total population as at 31.12.2006. Data can be accessed at: www.destatis.de.

In addition, we consider a large number of socio-economic characteristics provided by the GSOEP that in previous studies have been found to have an impact on life satisfaction. These include net household income (after tax), citizenship, age, number of persons in household, gender, marital status⁷, employment status, years spent in education, and health status (see e.g. Dolan et al., 2008). We further control for housing costs per m² (square meter).⁸ Both net household income and housing costs per m² are adjusted in two ways. First, we deflate both variables via a consumer price index to account for the fact that nominal increases in these variables do not affect people's life satisfaction, whereas real increases do. Second, we apply equivalence scales to account for the fact that the needs of a household grow with the number of members in it, albeit not proportionally (due to economies of scale in consumption).⁹ To capture the unit costs of migration, we use Euclidean distance as a measure for migration distance calculated from the coordinates of the centroids of the municipalities. Summary statistics for variables in our baseline model are provided in Appendix A.2.

To control for bias from other sources that are not standard controls in life satisfaction analyses, we consider additional characteristics in expansions of the baseline model. First, we control for housing (size, construction year, ownership, equipment, condition of the flat/house) and neighborhood characteristics.¹⁰ Second, we consider the extent of social participation by calculating an equally weighted mean of the frequency of responses to 'helping out friends, relatives or neighbors' and 'meeting friends, relatives or neighbors,' as suggested by Headey et al. (2013). Third, we control for economic characteristics of regions. We use Euclidean distance from each municipality to the nearest large city to control for accessibility of services provided in large cities.¹¹ To control for the prosperity of a region, we

⁷ To control for any effects from moving in with a partner, we combine this with information on marital status ("being married", etc.) (see Luechinger, 2009).

⁸ The GSOEP provides information on rents for tenants and imputed rents, which are estimated rents for house owners and tenants with reduced rents (see Krause (1996) for more information). Rents are the monthly rent charged, including utilities but excluding heating costs. Rents are divided by the size of the flat/house to obtain a measure for rents per unit of housing.

⁹ In line with the modified OECD scale, we assign a value of 1 to the first person in the household, 0.5 to every other person aged 14 and older, and 0.3 to all children below the age of 14. Housing costs and net household income are both divided by the sum of these values, resulting in needs-adjusted values (see Atkinson and Bourguignon, 2000). The advantage of using equivalence scales is that the effects of marginal changes in these variables can be interpreted on a hypothetical per-person basis.

¹⁰ Zumbro (2014) controls for housing characteristics using GSOEP to analyze the relationship between life satisfaction and home ownership.

¹¹ We define large cities on the basis of BBSR structural municipality types: (1) major large cities, (2) large cities in agglomeration counties, and (3) large cities in urban counties; see Table A.3 in the Appendix.

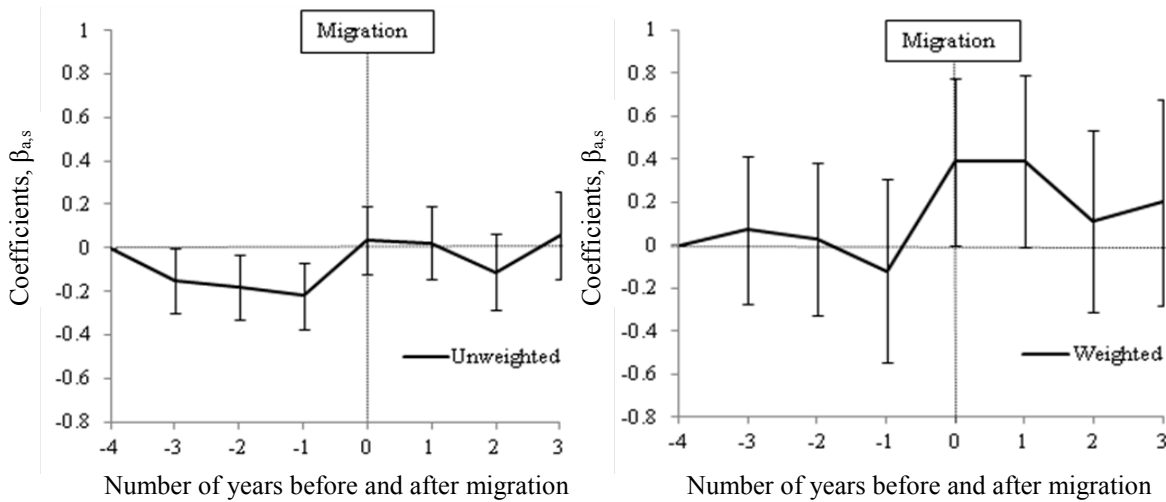


Fig. 1: The dynamic effect of migration on life satisfaction using an unweighted and a weighted estimator
 Source: Own calculations. Panel weights as provided by GSOEP are used. Error bars indicate 90 % confidence intervals.

Socio-economic controls include real equivalent household income, age of the individual, number of persons in household, hospital stay, marital status, working status and moves ‘within’ municipalities.

also use information on regional purchasing power and regional unemployment obtained from the BBSR. Finally, for the instrumentation of income we use predicted labor earnings. These are obtained by regressing the natural logarithm of labor earnings provided by GSOEP for each individual on industry and occupation dummies for each year, separately for West and East Germany. The exponential of the predicted value is summed up over household members, which yields a final measure on predicted labor earnings (see Vendrik, 2013).¹² When instrumenting income with predicted labor earnings, we extend the empirical model with additional controls for labor characteristics (contract length, job tenure, actual working hours and its squared term). Summary statistics for variables used in extensions of the baseline model are presented in Table A.4 in the Appendix.

5. Empirical Results

5.1 Unweighted vs. weighted estimation

Empirical results of the dynamic effect of migration on life satisfaction from an *unweighted estimation* are presented in the graph on the left hand side of Figure 1. The analysis is based on the assumption that the period when migration is assumed to affect life satisfaction spreads over seven years. It begins three years prior to the year when an

¹² Following Luechinger (2009), we exclude self-employed people from the sample before estimating labor earnings, as they tend to be more reluctant to state their income.

(1)					
Baseline Model					
Life satisfaction	Coef.	t-stat		Coef.	t-stat
<i>Socio-economic characteristics</i>					
Ln real equivalent net household income	0.1279 *	1.91	Not working	<i>Reference group</i>	
Ln real equivalent household rents/m ²	-0.0079	-0.42	Unemployed	-0.5048 ***	-5.38
Age squared	0.0008 *	1.87	Student	0.0914	0.67
Number of people living in hh	0.1154 **	2.17	Military, civilian services	-0.0714	-0.44
Number of children	0.0919	1.45	Working	0.0453	0.58
Not hospitalized last year	<i>Reference group</i>		German Citizen	<i>Reference group</i>	
Hospitalized last year	-0.1107 **	-2.33	Non-German citizen	0.4445 *	1.85
Single, not living with partner	<i>Reference group</i>		First interview	0.2518 **	2.42
Single, living with partner	0.0382	0.29	Second interview	0.0914	1.03
Married, living with partner	0.0467	0.24	Third or subsequent interview	<i>Reference group</i>	
Separated, not living with partner	-0.4508	-1.59	No moves 'within' municipalities	<i>Reference group</i>	
Separated, living with partner	-0.0140	-0.05	Move 'within' municipalities	0.0101	0.14
Divorced, not living with partner	-0.0634	-0.20	<i>Effects from migration</i>		
Divorced, living with partner	-0.4271	-1.33	Not migrating 'across' municipalities	<i>Reference group</i>	
Widowed, not living with partner	-0.4879	-0.97	Migrating 'across' municipalities	0.3101 **	2.46
Widowed, living with partner	0.3577	0.49	Migration distance	-0.0174	-0.19
Years in education	0.0073	0.25			
Individual fixed effects	Yes		Average observation per person	4.6	
Year effects	Yes		Observations	43,941	
Number of persons	9,562		Adjusted R-squared within	0.0181	

Tab. 1: Migration effects and satisfaction with life across German municipalities

Source: Own calculations. Model estimated by OLS. Robust standard errors are clustered for person number, and t-statistics are reported. * indicates significant at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level.

individual migrates (time zero, indicated by the vertical line) and ends three years after the migration event. Empirical results show that life satisfaction drops to a level significantly lower than zero three years before the year of migration and remains negative till the year preceding the migration event. The migration event increases life satisfaction reaching its initial level. Thereafter, life satisfaction remains at the level of time zero after the migration event. This is in line with what has been found by Nowok et al. (2013).

In a second step, we test whether these findings still hold when using a *weighted estimation*. The graph on the right hand side of Figure 1 shows that life satisfaction remains at the level of time zero the years before migration and shifts upward after the migration event. In addition, there is some weak evidence that life satisfaction remains significantly different from zero the years after the migration event. This suggests that the finding of negative effects before the migration event results from differences in the sampling design over and against the true population. When using panel weights to adjust for these differences, we find positive effects resulting from migration instead. In line with economic theory, this pattern would be compatible with the hypothesis of migration providing benefits deriving from changes in regional amenities when further factors that are related to the decision to migrate are controlled for.

5.2 Weighted baseline model

The results of the *baseline model* are presented in Table 1. The effects of socio-economic characteristics on life satisfaction are similar to those typically found in the literature (see Dolan et al., 2008). Our findings indicate a positive diminishing effect of income on life satisfaction. The effect of housing costs per m² on life satisfaction is negative but insignificant. We also find a positive effect of age squared, which is in line with a U-shaped relationship between age and life satisfaction established in earlier studies (see Ree and Alessie, 2011).¹³ Furthermore, the number of persons living in a household positively affects life satisfaction, while hospitalization in the previous year or redundancy have a negative effect. Being a non-German citizen or having the first interview relative to having the third or subsequent interview have a positive effect on life satisfaction. While effects from moving ‘within’ municipalities are close to zero and insignificant, we find a positive and significant effect on life satisfaction from migrating ‘across’ municipalities. Not only is the effect from migration statistically significant at the 5 percent level, it also exerts an effect equivalent to

¹³ In our model, the level effect of individual age is absorbed by individual fixed effects.

Life satisfaction	(1)		(2)	
	Baseline Model		Housing	
	Coef.	t-stat	Coef.	t-stat
<u>Socio-economic characteristics</u>				
Ln real equivalent net household income	0.1645 **	2.15	0.1707 **	2.29
Ln real equivalent household rents/m ²	-0.0164	-0.88	-0.0436 **	-1.98
<u>Migration effects</u>				
Not migrating 'across' municipalities	<i>Reference group</i>		<i>Reference group</i>	
Migrating 'across' municipalities	0.3007 **	2.49	0.2918 **	2.52
Migration distance	-0.0652	-0.51	-0.0557	-0.45
<u>Housing and neighborhood characteristics</u>				
Logarithm of size of house/flat in m ²			-0.0980	-1.13
Construction year: < 1918			-0.0319	-0.17
Construction year: 1918 - 1948			0.0202	0.11
Construction year: 1949 - 1971			0.0541	0.32
Construction year: 1972 - 1980			-0.0818	-0.49
Construction year: 1981 - 1990			-0.5441 ***	-2.84
Construction year: 1991 - 2000			0.0839	0.47
Construction year: > 2000			<i>Reference group</i>	
Not owner of house/flat			<i>Reference group</i>	
Owner of house/flat			-0.3061 ***	-2.82
No central heating			<i>Reference group</i>	
With central heating			0.1953	1.50
No balcony/terrace			<i>Reference group</i>	
With balcony/terrace			-0.0621	-1.11
No basement			<i>Reference group</i>	
With basement			-0.0605	-0.87
No garden			<i>Reference group</i>	
With garden			-0.0828	-1.10
No kitchen in house/flat			<i>Reference group</i>	
Kitchen in house/flat			0.0380	0.14
With hot running water/boiler in house/flat			<i>Reference group</i>	
No hot running water/boiler in house/flat			-0.1913	-0.85
No telephone in house/flat			<i>Reference group</i>	
With telephone in house/flat			0.3408 **	1.98
House/flat in good shape			<i>Reference group</i>	
House/flat needs to be refurbished			-0.0938 *	-1.96
Detached or semi-detached house			<i>Reference group</i>	
Farm building			-0.4176	-1.28
Terraced house			0.1263	0.84
Apartment or other building			-0.1694	-1.44
High-rise building			-0.7798 ***	-2.70
Private household			<i>Reference group</i>	
Hall of residence/home			0.3062	0.93

Life satisfaction	(1)		(2)	
	Baseline model		Housing	
	Coef.	t-stat	Coef.	t-stat
Industrial area			<i>Reference group</i>	
Residential area with old buildings			0.4705 **	2.45
Residential area with new buildings			0.5835 ***	2.91
Mixed or other area			0.4446 **	2.40
Commercial center			0.7178	1.13
Individual fixed effects	Yes		Yes	
Year effects	Yes		Yes	
Panel weights	Yes		Yes	
Number of persons	9,315		9,315	
Average observation per person	4.5		4.5	
Observations	41,764		41,764	
Adjusted R-squared within	0.0172		0.0220	

Tab. 2: Migration effects, housing and neighborhood characteristics

Source: Own calculations. All models estimated by OLS. Robust standard errors clustered for person number and t-statistics reported. * indicates significant at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level. Socio-economic controls as provided in Table 1 are included but not presented here.

more than half the magnitude of the effect of negative events on life satisfaction, such as redundancy (0.3101 as compared to -0.5048 for redundancy). The effect of migration distance (our measure for the costs of migration) on life satisfaction is negative, as expected, but insignificant.

5.3 Extensions of the weighted baseline model

To rule out omitted-variable bias, the model specifications presented in the following expand the baseline model by successively adding control variables that may simultaneously affect the dependent variable (life satisfaction) and the decision to migrate. This reduces our sample size. To account for this reduction, we compare the results of the extension to the previous model specification with adjusted sample size to assess the impact of further controls on migration effects. To ensure that the number of migrants is sufficiently large, we only retain those new control variables in subsequent model specifications if they have an impact on migration effects.

In a *first extension of the baseline model* presented in Table 2, we control for housing and neighborhood characteristics. Changes in housing and neighborhood characteristics may simultaneously affect life satisfaction and the decision to migrate. They may also bias the migration effect upwards or downwards, depending on whether migration involves an improvement or a deterioration of housing and neighborhood characteristics. Including

	(1)		(2)	
	Housing		Housing & social ties	
Life satisfaction	Coef.	t-stat	Coef.	t-stat
<i>Socio-economic characteristics</i>				
Ln real equivalent net household income	0.3015 ***	2.70	0.3043 ***	2.72
Ln real equivalent household rents/m ²	-0.0920 **	-2.36	-0.0958 **	-2.45
<i>Migration effects</i>				
Not migrating 'across' municipalities	<i>Reference group</i>		<i>Reference group</i>	
Migrating 'across' municipalities	0.4330 **	2.35	0.4277 **	2.33
Migration distance	-0.1394	-0.78	-0.1302	-0.75
<i>Social ties</i>				
Social participation			0.1257 ***	3.01
Individual fixed effects	Yes		Yes	
Year effects	Yes		Yes	
Number of persons	9,120		9,120	
Average observation per person	2.7		2.7	
Observations	24,280		24,280	
R-squared within	0.0323		0.0344	

Tab. 3: Migration effects and social ties

Source: Own calculations. All models estimated by OLS. Robust standard errors clustered for person number and t-statistics reported. * indicates significant at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level. Socio-economic controls as provided in Table 1 are included but not presented here.

housing and neighborhood controls reduces the sample size from 43,941 to 41,764 and the number of 'across'-municipality migrants from 555 to 465. In column (2) of Table 2, we find that living in a house constructed between 1981 and 1990 negatively affects life satisfaction compared to living in a house constructed after the year 2000. Our findings also suggest that life satisfaction is negatively affected by living in a high-rise building as opposed to a detached or semi-detached house, owning the house/flat, or the need for refurbishment of living quarters. Having a telephone positively affects life satisfaction. Finally, living in a residential area with old or new buildings or living in a mixed or other area has a positive effect on life satisfaction compared to living in an industrial area. Of these effects, that of living in a residential area with new buildings is the most influential.

As we see in Table 2, controlling for housing and neighborhood characteristics (column 2) has a minor effect on the coefficients included in the baseline model (column 1); the estimated coefficient for migration is 3 percent lower. Similarly, the income coefficient decreases, while its level of significance increases to the 5 percent level. The coefficient of housing costs is now significant at the 5 percent level in both specifications presented in Table 2. The effect of migration distance remains negative and insignificant.

Life satisfaction	(1)		(2)	
	Coef.	t-stat	Coef.	t-stat
<u>Socio-economic characteristics</u>				
Ln real equivalent net household income	0.1707 **	2.29	0.1740 **	2.33
Ln real equivalent household rents/m ²	-0.0436 **	-1.98	-0.0441 **	-2.01
<u>Migration effects</u>				
Not migrating 'across' municipalities	<i>Reference group</i>		<i>Reference group</i>	
Migrating 'across' municipalities	0.2918 **	2.52	0.2781 **	2.43
Migration distance	-0.0557	-0.45	-0.0441	-0.39
<u>Regional economic characteristics</u>				
Distance from the nearest large city			0.0011	0.18
Ln regional real purchasing power			1.3735 **	2.47
Regional unemployment			-0.0055	-0.39
Individual fixed effects	Yes		Yes	
Year effects	Yes		Yes	
Number of persons	9,315		9,315	
Average observation per person	4.5		4.5	
Observations	41,764		41,764	
R-squared within	0.0220		0.0227	

Tab. 4: Migration effects and regional economic characteristics

Source: Own calculations. All models estimated by OLS. Robust standard errors clustered for person number and t-statistics reported. * indicates significant at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level. Socio-economic controls as provided in Table 1 are included but not presented here.

In a *second extension of the baseline model* presented in Table 3, we add information on social participation as a measure of social ties. Existing social ties with the destination region may (a) simultaneously and positively affect life satisfaction and the decision to migrate and (b) bias migration effects upwards.¹⁴ As information on social ties is only available for three years in our sample period, the inclusion of social ties reduces the sample size from 41,764 to 24,280 and the number of migrants from 465 to 280.

Our results presented in Table 3 suggest that social ties have a positive and highly significant effect on life satisfaction. Comparing columns (1) and (2), the effect on migration and on socio-economic characteristics is, however, largely negligible. The effect on migration is 1 percent smaller. The effect of migration distance remains negative and insignificant. There is no change regarding the effect of income, but the coefficient is now significant at the 1 percent level compared to the results presented in Tables 1 and 2. The coefficient for housing costs per m² is significant at the 5 percent level in both specifications presented in Table 3; the negative coefficient is 4 percent larger when controlling for social ties. Overall,

¹⁴ Social ties in the region of origin might bias the migration effect as well, causing, however a downward bias. In general, we are more concerned with overestimating benefits from regional amenities. For this reason, we do not consider this further.

	(1) Housing & economic		(2) Housing, economic & labor		(3) Final Model: Housing, economic, labor & instrumentation	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
<i>Life satisfaction</i>						
<i>Socio-economic characteristics</i>						
Ln real equivalent net household income	0.3589 ***	4.36	0.3514 ***	4.35	1.3900 **	2.47
Ln real equivalent household rents/m ²	-0.0437 *	-1.69	-0.0437 *	-1.69	-0.0554 **	-2.13
<i>Migration effects</i>						
Not migrating 'across' municipalities	<i>Reference group</i>		<i>Reference group</i>		<i>Reference group</i>	
Migrating 'across' municipalities	0.2853 ***	2.87	0.2817 ***	2.80	0.2952 ***	2.98
Migration distance	-0.1508 *	-1.69	-0.1542 *	-1.73	-0.1443 *	-1.66
<i>Labor characteristics</i>						
Permanent contract	<i>Reference group</i>		<i>Reference group</i>		<i>Reference group</i>	
Temporary contract			-0.0631	-0.89	0.0018	0.02
Job tenure			-0.0145 **	-1.81	-0.0127	-1.64
Actual working hours			0.0284 ***	2.73	0.0278 ***	2.61
Actual working hours squared			-0.0003 ***	-2.66	-0.0004 ***	-2.73
					First stage	
Log of predicted labor earnings					0.0782 ***	6.87
Individual fixed effects	Yes		Yes		Yes	
Year effects	Yes		Yes		Yes	
Number of persons	6,894		6,894		6,894	
Average observation per person	4.3		4.3		4.3	
Observations	29,675		29,675		29,675	
Kleibergen-Paap rk LM statistic	-		-		40.567 ***	
Kleibergen-Paap rk Wald F statistic	-		-		47.182	

Tab. 5: Migration effects and income instrumentation

Source: Own calculations. All models estimated by OLS. Robust standard errors clustered for person number and t-statistics reported. * indicates significant at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level. Socio-economic controls as provided in Table 1 are included but not presented here.

controlling for social ties causes major observation losses and only has a negligibly minor impact on migration effects. Accordingly, we forgo consideration of social ties in subsequent model specifications.

In a *third extension of the baseline model* presented in Table 4, we control for regional economic characteristics alongside housing and neighborhood characteristics. The sample is that of the model with housing and neighborhood characteristics. We find that an increase in regional purchasing power has a positive diminishing effect on life satisfaction, which is significant at the 5 percent level. These findings suggest that the wealth of a region, as measured by purchasing power, provides positive externalities for individuals living in that region. Other regional economic characteristics, such as distance from the nearest large city and regional unemployment levels, have no significant effect on life satisfaction.

Comparing columns (1) and (2) of Table 4, we find that controlling for regional economic characteristics reduces the coefficient of migration by 5 percent. The effect of migration

distance remains negative and insignificant. The effect on socio-economic characteristics is small: the positive coefficient for income is 2 percent larger, while the negative coefficient for housing costs per m² increases by 1 percent.

In a *fourth and final extension of the baseline model* presented in Table 5, we instrument income using predicted labor earnings while controlling for housing, neighborhood and regional economic characteristics. This reduces the sample size from 41,764 to 29,675 and the number of migrants from 465 to 340. We compare the results of two specifications without income instrumentation to the one with instrumentation: a specification with housing, neighborhood, and regional economic characteristics (column 1), a specification with further controls for labor characteristics (column 2) (see Luechinger, 2009 or Vendrik, 2013), and, finally, a specification instrumenting for income (column 3).¹⁵ In the non-instrumented model with labor characteristics in (column 2), we find that job tenure has a negative impact on life satisfaction and that actual working hours have a highly significant inverse U-shaped effect as established in the literature (see Luechinger, 2009). Comparing the results to those in column (1), we find that controlling for labor characteristics has a small effect on the estimated coefficients for income, housing costs per m², and migration (maximum 2 percent change). The effect of migration distance is still negative, but compared to the results presented in Table 4, it is now significant at the 10 percent level in all specifications presented in Table 5.

When instrumenting the income variable (column 3 in Table 5), we find that the instrument passes the under-identification test of Kleibergen-Paap rk LM statistic of 40.57 (at a significance level of 1 percent) and the weak identification test of Kleibergen-Paap rk Wald F statistic of 47.18 (compared to the conventional required value of 10). Comparing the results in columns (2) and (3), we find that the income coefficient is more than three times larger when instrumented.

Instrumenting the income variable has an effect on the coefficients of other control variables as well. The positive effect of migrating on life satisfaction increases, the coefficient is 5 percent larger. The negative effect of housing costs per m² increases by more than 25 percent. The negative effect of migration distance decreases by 6 percent. Our results confirm earlier studies (e.g. Luechinger, 2009 or Vendrik, 2013) in underlining the importance of controlling for income endogeneity in empirical life-satisfaction analyses.

¹⁵ Following Luechinger (2009), we also drop self-employed people from the sample in this model specification because they tend to be more reluctant about disclosing their income.

6. Robustness

The previous section has confirmed the importance of income instrumentation in our analysis. In the following, we use the *specification with income instrumentation* (fourth and final extension of the model; column (3) of Table 5) for a number of robustness checks. First, we examine the robustness of socio-economic and migration effects to adding further controls for labor characteristics, which are used in the literature when instrumenting the income variable with predicted labor earnings (see Luechinger, 2009) and which we have not yet considered in our final model specification. More specifically, we additionally control for job status (blue-collar, white-collar, managerial position, public services, trainee). The results (not presented) are similar to those found in our final model specification (Table 5, column 3).

Second, we tested various other specifications of distances to cities (used as a control for regional economic characteristics in column (2), Table 4) to rule out any effect from the choice of the distance variable on the outcome of our analysis. As an alternative to Euclidean distance from large cities, we used driving distance to major centers provided by the BBSR. “Major centers” captures not only large cities, but also smaller cities that function as major centers. We also tested for various specifications, including distance variables as squared terms, in addition to the level and a logarithmic transformation. None of these different specifications (not presented) yield higher significance levels for coefficients, nor do effects from migration change, the main focus of our analysis.

7. Monetizing Regional Amenities

Using the marginal rate of substitution between the effect of migration and individual income, it is possible to assign a monetary value to the trade-off between income and migration. According to our theoretical model, this provides us with information about the income changes required to offset changes in regional amenities, which can be calculated as follows:

$$\text{WTP for regional amenities} = - \frac{\delta Y}{\delta A} \Big|_{dLS=0} = \frac{\hat{\beta}_a}{\beta_y} Y_m \quad (11)$$

with Y being real equivalent net household income, A the migration dummy, β_a the estimated coefficients of the migration dummy, β_y the coefficients of the logarithm of real equivalent net household income, and Y_m median real equivalent net household income.

	Evaluated in terms of monthly median income of € 1,764		
	Estimate	z-value	% of income
Regional amenities	371 **	1.99	21
Housing costs ^a	-48 *	-1.86	3
Migration distance ^b	-23	-1.34	1.5

Tab. 6: WTP estimates for regional amenities, housing costs, and migration distance per person. Source: Own calculations. Estimates derived from column (3) of Table 5. Robust standard errors clustered for person number. T-statistics obtained using the delta method. * indicates significant at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level. ^a WTPs for housing costs evaluated in terms of real median equivalent rents per m² of € 2 (adjusted by OECD equivalence scale, see Section 4) and median change in the size of house/flat for migrants of 15 m². ^b WTPs for migration distance evaluated in terms of median migration distance of 13 km.

Using results from column (3) in Table 5, the WTP of migrants for an increase in regional amenities provided by the monthly income change is € 371 (evaluated in terms of a monthly median household income of € 1,764, see Table 6), which is statistically significant at the 5 percent level, equivalent to 21 percent of household income.¹⁶ As we do not account for discounted future income, this value can stand as a short-term measure of the benefits from regional amenities (see Schündeln, 2007, for further discussion).

Analogously to obtaining a WTP for an increase in regional amenities, we calculate for migrants a WTP for lower housing costs and shorter migration distance (our measure of the costs of migration) as follows:

$$\text{WTP for housing costs} = - \frac{\delta Y}{\delta R} \Big|_{dLS=0} = \frac{\hat{\beta}_h}{\hat{\beta}_y} \frac{Y_m}{R_m} \Delta S_m \quad (12)$$

$$\text{WTP for migration distance} = - \frac{\delta Y}{\delta D} \Big|_{dLS=0} = \frac{\hat{\beta}_d}{\hat{\beta}_y} Y_m D_m \quad (13)$$

with Y being real equivalent net household income, R real equivalent housing costs per m², D distance of migration, β_h estimated parameter for real equivalent housing costs per m², β_d estimated parameter for migration distance, β_y estimated parameter for the logarithm of real equivalent net household income, Y_m median of real equivalent household income, R_m median of real equivalent housing costs per m², ΔS_m change in the size of house/flat for migrants, and D_m median migration distance in km.

The WTP of migrants for a decrease in housing costs as provided by the monthly income change is € 48 (evaluated in terms of monthly median equivalent housing costs per m² of € 2

¹⁶ Evaluated in terms of a mean monthly household income of € 2,089, WTP for changes in regional amenities is € 439.

and the median change in size of house/flat of 15 m², see Table 6), which is statistically significant at the 10 percent level, corresponding to 3 percent of household income.¹⁷ The WTP for a decrease in migration distance as provided by the monthly income change is € 23 (evaluated in terms of a median migration distance of 13 km, see Table 6), which represents 1.5 percent of household income.¹⁸ However, the WTP for migration distance is statistically no different from zero.

Several issues concerning the value of regional amenities as provided by WTP estimates are worthy of note. First, accounting for income endogeneity has a considerable effect on our empirical results. As the income coefficient is used as a denominator when calculating the trade-off between income and regional amenities, estimates for regional amenities would be overestimated if income were not instrumented; in our case values would be 3.5 times larger. Our value is slightly above the findings in the literature, according to which estimates increase by a factor of between two and three when instrumenting income with predicted labor earnings (see Luechinger, 2009 or Vendrik, 2013). However, these studies also tend to consider much longer sample periods.

Second, accounting for migration costs in the empirical model is of major importance, as otherwise, changes in life satisfaction understate the correct value of changes in regional amenities. If people decide to migrate to a specific region, *ceteris paribus*, benefits from regional amenities must be large enough to cover migration costs. In Bayer et al. (2009), for example, the estimated benefits of better air quality are 3.5 times higher in a residential sorting model compared to results of a hedonic regression without migration costs.¹⁹ Our estimates suggest that benefits from regional amenities are 1.5 times larger when controlling for migration costs (results for a model without migration costs are not presented).²⁰ Accordingly, accounting for migration costs is of major importance not only in hedonic analyses but also in life-satisfaction analyses aiming at estimating benefits from regional amenities based on migration decisions.

¹⁷ Evaluated in terms of a monthly mean household income of € 2,089 and monthly mean rents per m² of € 26, WTP for changes in housing costs is € 51.

¹⁸ Evaluated in terms of a monthly mean household income of € 2,089 and a mean migration distance of 57 km, WTP for migration distance is € 119.

¹⁹ The WTP for a one-unit reduction in ambient concentration of particulate matter increases from \$55 to \$185 per year.

²⁰ Measures for benefits from regional amenities decrease from € 370 evaluated in terms of median household income (€ 439 evaluated in terms of mean household income) to € 265 (€ 313). This represents a reduction from 21 % of household income to 15 %.

Third, accounting for housing costs per m² in the empirical model has a negligible effect on our estimates for benefits from changes in regional amenities compared to accounting for migration costs. However, this does not in itself suggest excluding housing costs per m² from empirical life-satisfaction analyses on internal migration. First, their level effects are controlled for by individual fixed effects in our analysis. Second, not only is their effect statistically different from zero, they also play a crucial role in explaining decisions to migrate by acting as a compensating counterpart to benefits from regional amenities indicated by the findings from our empirical analysis.

8. Conclusions

This study links economic theory with life-satisfaction analyses referring to internal migration and reassesses empirical findings. We derive the empirical life satisfaction model from an extension of the Roback (1982) model that accounts for benefits from regional amenities in the utility function, while controlling for income, housing costs, and migration costs. We find that the use of panel weights substantially changes earlier empirical findings: life satisfaction remains insignificantly different from zero the years before migration and shifts upward significantly after the migration event. In line with economic theory, this pattern would be compatible with the hypothesis of migration providing benefits deriving from changes in regional amenities when further factors such as individual characteristics, housing characteristics, social ties, and regional economic characteristics are controlled for. The major advantages of our analysis are its high level of regional disaggregation combined with individual panel information, thus permitting not only a detailed analysis of migration decisions, but also controlling for selection bias by applying individual fixed effects. To account for endogeneity of income, we apply an instrumentation strategy.

We find that benefits from changes in regional amenities due to migration represent 21 percent of household income. These benefits from regional amenities are much larger than migration-related income gains, which represent only 3 percent of household income. These benefits are partly offset by housing costs and migration costs representing 3 percent and 1.5 percent of household income, respectively. In statistical terms, however, migration costs are not significantly different from zero.

Several insights from our robustness analyses are worthy of note. First, benefits from changes in regional amenities are overestimated if endogeneity of income is not accounted for, the value then being 3.5 times larger. This is close to findings in the literature. Second,

the consideration of migration costs in our empirical life-satisfaction model turns out to increase benefits from regional amenities by a factor of 1.5. This emphasizes the importance of controlling for migration costs in empirical life-satisfaction analyses to avoid omitted variable bias when looking to derive benefits from regional amenities as recognized with regard to hedonic studies.

Appendix

Appendix A.1:

Assuming a Cobb-Douglas utility function, the maximization problem that yields the indirect utility function is stated as the following maximization problem:

$$\max_{C,H} L = C_{i,j}^{\alpha_c} H_{i,j}^{\alpha_h} e^{\beta_a A_j} e^{\beta_{mc} MC_i} + \lambda (Y_{i,j} - C_{i,j} - R_{i,j} H_{i,j})$$

In a first step, we take the first derivatives of the Lagrangian with respect to consumption and housing:

$$(1) \alpha_c C_{i,j}^{\alpha_c-1} H_{i,j}^{\alpha_h} e^{\beta_a A_j} e^{\beta_{mc} MC_i} = \lambda$$

$$(2) \alpha_h C_{i,j}^{\alpha_c} H_{i,j}^{\alpha_h-1} e^{\beta_a A_j} e^{\beta_{mc} MC_i} = \lambda R_{i,j}$$

In a second step, we divide (1) by (2):

$$(\alpha_c/\alpha_h) (H_{i,j}/C_{i,j}) = 1/R_{i,j}$$

In a third step, we solve for $C_{i,j}$ and $H_{i,j}$, which yields optimal consumption bundles:

$$C_{i,j}^* = Y_{i,j} / (1 + (\alpha_h/\alpha_c))$$

$$H_{i,j}^* = Y_{i,j} / ((\alpha_c/\alpha_h) R_{i,j} + R_{i,j})$$

Finally, we put optimal consumption bundles into the utility function and take the logarithm.

This yields the indirect utility function:

$$\ln V_{i,j} = \beta + \beta_y \ln Y_{i,j} - \beta_h \ln R_{i,j} + \beta_a A_j + \beta_{mc} MC_i,$$

where α_h/β_y is the fraction of income spent on housing, $\beta = \alpha_c \ln(\alpha_c/(\alpha_c + \alpha_h)) + \alpha_h \ln(\alpha_h/(\alpha_c + \alpha_h))$,

$\beta_y = \alpha_c + \alpha_h$ and $\beta_h = \alpha_h$.

Appendix A.2: Summary statistics for the baseline model

Variable	Mean	SD	Year
Life satisfaction			
Life satisfaction (1 = very dissatisfied and 10 = very satisfied)	6.9586	1.7298	2006-2010
Income and housing			
Ln real net household equivalent income (log of Euros)	9.9093	0.5298	2006-2010
Ln real rents per square meter (log of Euros)	2.7090	1.4136	2006-2010
Demographic characteristics			
Number of persons living in household	2.9083	1.2313	2006-2010
Number of children in household	0.6020	0.9242	2006-2010
Age of individual squared	2,185	976	2006-2010
Health status			
*No hospitalization last year (1 = yes, 0 = no)	0.9056	0.2924	2006-2010
Hospitalization last year (1 = yes, 0 = no)	0.0944	0.2924	2006-2010
Marital status			
*Single, not living with partner (1 = yes, 0 = no)	0.1522	0.3592	2006-2010
Single, living with partner (1 = yes, 0 = no)	0.0538	0.2256	2006-2010
Married, living with partner (1 = yes, 0 = no)	0.6727	0.4692	2006-2010
Separated, not living with partner (1 = yes, 0 = no)	0.0126	0.1117	2006-2010
Separated, living with partner (1 = yes, 0 = no)	0.0033	0.0574	2006-2010
Divorced, not living with partner (1 = yes, 0 = no)	0.0557	0.2293	2006-2010
Divorced, living with partner (1 = yes, 0 = no)	0.0295	0.1693	2006-2010
Widowed, not living with partner (1 = yes, 0 = no)	0.0160	0.1254	2006-2010
Widowed, living with partner (1 = yes, 0 = no)	0.0042	0.0644	2006-2010
Education level			
Years in education	12.5101	2.6947	2006-2010
Employment status			
*Non-working (1 = yes, 0 = no)	0.1451	0.3523	2006-2010
Unemployed (1 = yes, 0 = no)	0.0569	0.2317	2006-2010
Student (1 = yes, 0 = no)	0.0183	0.1340	2006-2010
Military, civilian services (1 = yes, 0 = no)	0.0087	0.0931	2006-2010
Working (1 = yes, 0 = no)	0.7709	0.4203	2006-2010
Citizen status			
*German citizen (1 = yes, 0 = no)	0.9462	0.2257	2006-2010
Non-German citizen (1 = yes, 0 = no)	0.0538	0.2257	2006-2010
Interview status			
First interview (1 = yes, 0 = no)	0.0195	0.1383	2006-2010
Second interview (1 = yes, 0 = no)	0.0214	0.1448	2006-2010
Third or subsequent interview (1 = yes, 0 = no)	0.9591	0.1981	2006-2010
Mover status			
*No moves (1 = yes, 0 = no)	0.9748	0.1569	2006-2010
Move 'within' municipalities (1 = yes, 0 = no)	0.0252	0.1569	2006-2010
Migration characteristics			
*Not migrating 'across' municipalities (1 = yes, 0 = no)	0.9874	0.1117	2006-2010
Migrating 'across' municipalities (1 = yes, 0 = no)	0.0126	0.1117	2006-2010
Migration distance (in 100 km)	0.0080	0.1503	2006-2010
Year dummies			
*Year 2006 (1 = yes, 0 = no)	0.2053	0.4039	2006-2010
Year 2007 (1 = yes, 0 = no)	0.2025	0.4019	2006-2010
Year 2008 (1 = yes, 0 = no)	0.1991	0.3993	2006-2010
Year 2009 (1 = yes, 0 = no)	0.1973	0.3980	2006-2010
Year 2010 (1 = yes, 0 = no)	0.1958	0.3968	2006-2010
Total number of observations	43,941		

Source: Own calculations based on GSOEP. *Reference categories. Following Luechinger (2009), variables describing marital status are a combination of standard information on marital status (such as being married) and living or not living together with a partner. Abbreviations: BBSR= Bundesinstitut für Bau-, Stadt- und Raumforschung; SD=Standard Deviation.

Table A.3: Settlement-structural municipality types aggregation

Aggregation	Settlement structural municipality types (BBSR)
<i>Large cities</i>	Major large city
	Large city in agglomeration county
	Large city in urban county
<i>Other regions</i>	Center of high-density agglomeration county
	Other municipality in high-density agglomeration county
	Center of dense agglomeration county
	Other municipality in dense agglomeration county
	Center of rural agglomeration county
	Other municipalities in rural agglomeration county
	Center of dense urban county
	Other municipality in dense urban county
	Center of rural urban county
	Other municipalities in rural urban county
	Center of rural county with higher density
	Other municipalities in rural county with higher density
	Center of rural county with lower density
	Other municipality in rural county with lower density

Source: Own compilation based on BBSR.

Table A.4: Summary statistics for extensions of the baseline model

Variable	Mean	SD	Year
Housing characteristics			
Ln size of house/flat in m ²	4.6548	0.4082	2006-2010
Construction year: < 1918	0.1511	0.3581	2006-2010
Construction year: 1918 - 1948	0.1472	0.3543	2006-2010
Construction year: 1949 - 1971	0.2254	0.4179	2006-2010
Construction year: 1972 - 1980	0.1400	0.3470	2006-2010
Construction year: 1981 - 1990	0.1287	0.3348	2006-2010
Construction year: 1991 - 2000	0.1536	0.3606	2006-2010
*Construction year: > 2000	0.0540	0.2261	2006-2010
*Not owner of house/flat	0.3914	0.4881	2006-2010
Owner of house/flat	0.6086	0.4881	2006-2010
*No central heating	0.0315	0.1747	2006-2010
With central heating	0.9685	0.1747	2006-2010
*No balcony/terrace	0.1726	0.3779	2006-2010
With balcony/terrace	0.8274	0.3779	2006-2010
*No basement	0.0445	0.2061	2006-2010
With basement	0.9555	0.2061	2006-2010
*No garden	0.2799	0.4490	2006-2010
With garden	0.7201	0.4490	2006-2010
*No kitchen in house/flat	0.0037	0.0604	2006-2010
Kitchen in house/flat	0.9963	0.0604	2006-2010
*No hot running water/boiler in house/flat	0.0021	0.0453	2006-2010
With hot running water/boiler in house/flat	0.9979	0.0453	2006-2010
*No telephone in house/flat	0.0039	0.0625	2006-2010
With telephone in house/flat	0.9961	0.0625	2006-2010
*House/flat in good shape	0.7211	0.4485	2006-2010
House/flat needs to be refurbished	0.2789	0.4485	2006-2010
*Detached or semi-detached house	0.4092	0.4917	2006-2010
Farm building	0.0331	0.1788	2006-2010
Terraced house	0.1896	0.3920	2006-2010
Apartment or other building	0.3586	0.4796	2006-2010
High-rise building	0.0096	0.0973	2006-2010
*Private household	0.9994	0.0235	2006-2010
Hall of residence/home	0.0006	0.0235	2006-2010
*Industrial area	0.0049	0.0699	2006-2010
Residential area with old buildings	0.3413	0.4742	2006-2010
Residential area with new buildings	0.4255	0.4944	2006-2010
Mixed or other area	0.2242	0.4171	2006-2010
Commercial center	0.0041	0.0637	2006-2010
Total number of observations	41,764		
Social ties			
Social participation	2.8419	0.6540	2006-2010
Total number of observations	24,280		
Regional economic characteristics at the municipality level			
Distance from nearest large cities (in km)	23.5681	23.7347	2006-2010
Ln real purchasing power (in € per head)	2.8633	0.1404	2006-2010
Regional unemployment (in %)	9.5958	4.8445	2006-2010
Total number of observations	41,764		
Labor characteristics			
Ln real equivalent predicted labor earnings (in €)	9.9478	0.6125	2006-2010
*Temporary contract	0.0833	0.2763	2006-2010
Permanent contract	0.9167	0.2763	2006-2010
Job tenure	12.6455	10.3285	2006-2010
Actual working hours	38.3714	12.9491	2006-2010
Actual working hours squared	1,640.0360	945.0331	2006-2010
Total number of observations	29,675		

Source: Own calculations based on GSOEP and BBSR.

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Paper 2:
A Human Well-being Approach for Assessing
the Value of Natural Land Areas*

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Abstract

To decide on the policy measures to be implemented, policymakers need comprehensive information on the costs and benefits of land conversion for society. Accordingly, the EU Biodiversity Strategy requires the member countries to assess their ecosystems and the economic value of those systems by 2020. This paper takes up and extends the subjective well-being approach to valuing changes in natural land cover, which provides information on willingness-to-pay for landscape amenities such as scenic views or recreational opportunities. Results at the NUTS 2 level for European countries indicate (a) that marginal willingness-to-pay estimates tend to be higher for natural areas that are scarcer, and (b) that a nonlinear relationship between land cover and well-being is preferred to a linear relationship indicating decreasing benefits from individual landscape amenities.

Keywords: ecosystem services, environmental valuation, Europe, subjective well-being, land coverage.

JEL codes: D1, I31, Q24, Q51, Q57

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1. Introduction

Ecosystem services generated on cultivated and natural land areas, such as food and bioenergy provisioning, climate regulation, and landscape amenities, are essential for the well-being of mankind (MA 2005). Population growth and increasing economic activity, however, cause such areas to be converted into artificial land areas and thus threaten the provisioning of these services. Accordingly, it is of major importance to society for policymakers to ensure that land is used sustainably by implementing dedicated policy measures.

To decide on such measures, policymakers must ensure that their benefits to society will outweigh the costs they involve. The German Renewable Energy Act (BMU 2012) has been implemented without conducting a comprehensive cost-benefit analysis. This act provides incentives for bioenergy provisioning without taking other ecosystem services to society (landscape amenities, etc.) or the functioning of ecosystems into account. These incentives have produced a substantial increase in the area of land used to crop maize for biogas production at the expense of cultivated and natural land usable for other purposes. The resulting “maize deserts” in the German landscape have led to a decrease in landscape amenities such as benefits from scenic views or recreational opportunities, and the well-being of people living in these regions has suffered as a consequence. There have also been functional deficiencies in the ecosystems and a loss of biodiversity, not only on the converted land itself but also in neighboring areas. This indicates how important it is for policymakers to weigh up all the costs and benefits of land conversion for society when deciding on the policy measures to be implemented.

To supply policymakers with the necessary information on the costs and benefits of such measures, economic analyses are needed that attach net economic values to land conversion that induces ecosystem service loss. This is why the European Commission has launched the EU Biodiversity Strategy (EC 2011), which requires all member countries to assess their ecosystems and the economic value of those systems by 2020. Economic analyses require information on the prices for ecosystem services, but for most such services, especially those not traded on markets, this information is not available. To obtain this information, economic methods for valuing nonmarket environmental goods can be applied. However, neither the European Biodiversity Strategy 2020 nor the literature provide any guidance on which of these methods to use.

The literature also displays various other limitations. (1) Studies based on preferential methods like contingent valuation or contingent choice modeling (see Mendelsohn and Olmstead 2009) differ in their research designs and methodologies, which limits comparability. (2) Studies only analyze services for single types of land cover and also have a clear regional focus (see, e.g., Mogas et al. 2006). In a broader perspective, the regional coverage across Europe and the number of services assessed so far have been low. To provide the information required by the EU Biodiversity Strategy, i.e. a comprehensive assessment of ecosystem services and their values, many more studies would be needed.

The objective of this article is to propose an alternative - the subjective well-being method - for valuing landscape amenities by analyzing people's preferences for particular types of natural¹ land cover. This method enables us to derive marginal willingness-to-pay (MWTP) estimates providing valuable information on the welfare implications of land cover changes. The advantage of the subjective well-being method is that it requires little in the way of research resources and can be consistently applied for many countries. Previous studies drawing upon information on subjective well-being to investigate preferences for environmental amenities have mostly looked at the amenity value of climate. Far fewer studies exist investigating other environmental aspects.² None of these studies has analyzed preferences for land cover. However, there is long-standing evidence in the literature for land cover preferences in housing markets (see Waltert and Schlöpfer 2010 for an overview), so we also expect to find such preferences in a subjective well-being framework.

This article avoids some of the limitations of existing research by using data from the second and most recent European Quality of Life Survey (EQLS) from the year 2007, which provides information on 31 European countries up to the NUTS 2 level for 292 regions with a total of 35,634 observations.³ The first advantage of this dataset is its high level of disaggregation. This is an asset because it has been established that the relationship between environmental amenities and subjective well-being is more significant at the local than at the national level (see Welsch 2006). The second advantage is that households disclose exact

¹ We distinguish between “artificial” and “natural” land cover throughout the paper, with the latter encompassing both cultivated and natural varieties.

² For a recent overview of the literature focusing on environmental aspects, see Welsch and Kühling (2009).

³ NUTS stands for Nomenclature des Unités Territoriales Statistiques, a classification system for dividing up the EU into regional economic territories. Category 2 provides the average population size in the region (between 800,000 and 3 million).

figures on their net incomes. Other datasets, including the European Value Survey and the European Social Survey, provide information on income deciles only.⁴

The remainder of the article is structured as follows: Section 2 reviews the environmental valuation literature on ecosystem services and briefly summarizes other researchers' attempts to estimate preferences for environmental amenities using the subjective well-being method. Section 3 presents the empirical model and describes the data used for the analysis. Section 4 reports the results of the econometric analysis and shows implicit MWTP estimates for changes in land cover. Section 5 discusses the limitations of the analysis and draws some conclusions.

2. Literature review

Environmental valuation methods based on stated preferences, such as contingent valuation or choice modeling, have been widely applied in attempts to value changes in ecosystem services by asking people to state their willingness-to-pay (WTP) (see Mendelsohn and Olmstead 2009 for a review). However, few studies exist that investigate people's preferences in connection with changes to the size of particular areas (see e.g. Mogas et al. 2006). More studies can be found that evaluate conservation programs for natural habitats (see e.g. Kramer and Mercer 1997, White and Lovett 1999, Lehtonen et al. 2003, Siikamaki and Layton 2007 and Adams et al. 2008). But here the area to be conserved is already covered by the biome in question, so the use of WTP estimates from these analyses to increase natural area in policy decisions may underestimate the true welfare implications.

Although stated preference methods are generally very flexible in their application, the surveys involved are costly and time-consuming. In addition, it is usually difficult to explain the full complexity of ecosystem services to respondents. As a consequence, values are typically site-specific and refer to only one or a few specific ecosystem services (see e.g. Birol et al. 2010). Furthermore, differences in research designs and the methodologies applied complicate comparisons across studies.

Revealed preference methods such as hedonic pricing infer preferences for changes to land cover from decisions on house purchases. Hedonic pricing methods have been widely applied for the valuation of changes to land cover in the U.S., while for Europe the evidence derived from this approach is limited (see Waltert and Schläpfer 2010 for an overview). There are

⁴ The EVS can be found on the following website: <http://www.europeanvaluesstudy.eu/>. The ESS is available on the following website: <http://ess.nsd.uib.no/>.

several studies that focus on scenic views (see, e.g., Gillard 1981 or Benson et al. 1998). An increasing number of studies explicitly focus on changes to land cover (see, e.g., Irwin 2002).

The advantage of the hedonic pricing method is that values for changes to land cover are directly derived from observed decisions. One major shortcoming of the method, however, is that it requires the housing market to be in equilibrium, which might not hold (see Greenwood et al. 1991).

A recent alternative in the field of environmental economics is the subjective well-being method. It is based on the assumption that environmental amenities are one of the factors determining quality of life. In this approach, life satisfaction is estimated as a function of factors such as environmental amenities and income, while at the same time controlling for other socio-economic, demographic, and geographical information. This estimated relationship is used to derive an implicit MWTP based on the marginal rate of substitution (MRS) between income and the environmental amenity in question.

The first empirical economic analysis of subjective well-being was conducted by Easterlin (1974), estimating at both the national and international level how changes in income affect happiness. A large body of literature now links subjective well-being with economic indicators (see Clark et al. 2008 or Welsch and Kuehling 2009 for an overview). A small but growing number of studies exist estimating the trade-off between life satisfaction and environmental amenities such as climatic conditions (see e.g. Frijters and van Praag 1998, Rehdanz and Maddison 2005, Brereton et al. 2008 and Moro et al. 2008), natural flood disasters (see e.g. Luechinger and Raschky 2009), the occurrence of drought (see Carroll et al. 2009), proximity to infrastructure (see Brereton et al. 2008), air quality (see e.g. Welsch 2006, Di Tella and MacCulloch 2007, Rehdanz and Maddison 2008, Luechinger 2009, MacKerron and Mourato 2009 and Levinson 2012), and scenic views (see, e.g., Ambrey and Fleming 2012).⁵

None of the previous studies based on self-reported levels of life satisfaction explicitly focuses on people's preferences for land cover. Studies investigating the amenity value of climate (e.g. Rehdanz and Maddison 2005 or Moro et al. 2008) only implicitly control for differences in natural land cover, since vegetation is determined by climate. However, the extent is limited since most of the natural areas, at least in densely populated industrialized countries, are converted for other uses and managed by humans. In addition to the conversion

⁵ For a recent overview on the literature focusing on environmental aspects, see Welsch and Kuehling (2009).

of natural areas into artificial areas, land management such as the irrigation of agricultural soil or the logging of forests can have major impacts on natural vegetation.

Exceptions are Brereton et al. (2008) and Ambrey and Fleming (2012), where the measure for land cover is based on proximity of infrastructure (such as landfill, hazardous waste facility, airports, etc.) or by a scenic view index constructed from an ex-ante survey on preferences for scenic views. Neither of these studies allow for the calculation of implicit MWTP estimates for changes in land cover.

The subjective well-being method has a number of methodological advantages compared to stated preferences. These assets are related to the fact that individuals are not explicitly asked to state their WTP for a specific ecosystem service. In a stated preferences framework, limitations may arise if people are not familiar with the ecosystem service in question. Other problems cropping up, such as insensitivity to the size of the service on the part of respondents (see Kahneman and Knetsch, 1992) or aversion to placing a value on ecosystem services as requested in stated preferences frameworks (see Welsch and Kuehling 2009), have no bearing on the subjective well-being method.

There are however limitations to the subjective well-being method. First, subjective well-being is considered a valid approximation for individual welfare as long as individuals with a higher latent utility also display greater life satisfaction (see Levinson 2012). Discrete choice models proceed on the same underlying assumption. Evidence shows that people who are satisfied with their lives are also rated accordingly by family members, friends, and experts (see Sandvik et al. 1993). Furthermore, life satisfaction scores are correlated with other variables that can be claimed to be associated with true individual well-being (see Frey and Stutzer 2002). Second, endogeneity of income could be an issue in subjective well-being analyses. Based on an income measurement error independent of the level of income, the coefficient can be biased towards zero (attenuation bias). Furthermore, omitted variables that correlate with life satisfaction, such as personality traits or commuting hours, can cause bias in the income coefficient. Finally, evidence shows that individuals compare their current income level with their peers and with past income situations (see Clark et al. 2008). In many studies, this cannot be controlled for due to data restrictions or difficulties in the establishment of peer groups. Given the challenges related to the estimation of the income coefficient, an overestimation of MWTP estimates may result (see Luechinger 2009).

3. Empirical approach

3.1 The econometric model

The following equation is designed to analyze the impact of land cover on life satisfaction while controlling for demographic, socio-economic, geographical, and climate characteristics:

$$LS_{ij} = \alpha + \beta \ln(Y_i) + \sum_{k=1}^o \gamma_k X_{ki} + \sum_{l=1}^p \delta_l G_{lj} + \sum_{m=1}^q \varphi_m C_{mj} + \sum_{a=1}^n \eta_a AS_{aj} + \tau_r + \varepsilon_{ij}, \quad (1)$$

where LS_{ij} represents reported life satisfaction of individual i in NUTS 2 region j , Y_i is reported household income of individual i , X_{ki} are demographic and socio-economic variables of individual i , G_{kj} is geographical information, C_{mj} stands for climate variables, AS_{aj} represents shares of different categories of land areas a in percent, and τ_r symbolizes country dummies.⁶ The variables G_{kj} , C_{lj} , and AS_{aj} are all measured at the NUTS 2 level. The error term is represented by ε_{ij} , and β , $\gamma_{(1,\dots,o)}$, $\delta_{(1,\dots,p)}$, $\varphi_{(1,\dots,q)}$ and $\eta_{(1,\dots,n)}$ are parameters to be estimated.

Various assumptions about the functional form of the econometric model are worth discussing. Following empirical findings regarding the functional form of income (see Layard et al. 2008), household income is introduced into the model with its natural logarithm. A quadratic term of age is included in addition to its level, to account for the U-shaped relationship found in the literature. Similarly, evidence for a nonlinear relationship of climate variables is provided in the literature, specifically for temperature, which is why temperature variables are entered as levels and squared terms.

We expand the standard subjective well-being model by introducing land cover information into the empirical model, a factor that has not been considered in the literature on subjective well-being so far. Similar to the other environmental amenities, land cover is considered on the regional level in the econometric model. The underlying assumption here is that the composition of natural areas closer to an individual affects life satisfaction more, while the composition of natural areas further away are less important. To make areas in land cover categories comparable between regions of different size, we consider shares of different types of land cover (in percent) at the regional level as an indicator. Since land cover shares sum up to 100 % for each region, one area category has to be excluded from the analysis. The resultant implicit assumption is that expansion or contraction always takes place at the

⁶ Area shares in percentage of category a land cover for each NUTS 2 region j are calculated as follows:

$$AS_{aj} = \left(\frac{A_{aj}}{\text{Total } A_{aj}} \right) \cdot 100, \text{ where } A_{aj} \text{ is the area of category } a \text{ land cover in NUTS 2 region } j \text{ expressed in km}^2.$$

expense of the reference category. The interpretation of land cover coefficients depends on the reference category excluded.

Considering shares of land cover in the econometric model enables us to analyze its linear effects. However, preferences for land cover may also depend on the current allocation of land area to specific categories. Preferences for one type of land cover may be higher (lower) if less (more) area of this category is already available. To account for this, nonlinearities are introduced into the model by replacing land cover shares by the natural logarithm of $(1 + AS_{aj})$.⁷

Implicit MWTP estimates can be derived from this estimated relationship. Individuals' MWTP for a 1 percent increase in land area can be derived by totally differentiating the estimated function setting $dLS = 0$. The MWTP for the linear model is then given by the MRS between income Y and area share AS_a :

$$\text{MWTP} = - \frac{\partial Y}{\partial AS_a} \Big|_{dSWB \equiv 0} = Y \frac{\eta_a}{\beta}. \quad (2)$$

A positive (negative) MWTP indicates the amount of this particular land area category to be increased (decreased) at the expense of the area category excluded. An optimal combination of land areas in terms of benefits from landscape amenities is given when the MWTPs are all equal to zero.

For the nonlinear specification the equation changes to

$$\text{MWTP} = - \frac{\partial Y}{\partial AS_a} \Big|_{dSWB \equiv 0} = \frac{Y}{(1+AS_a)} \frac{\eta_a}{\beta}. \quad (3)$$

In contrast to the linear specification, MWTPs derived from the nonlinear model differ depending on the given allocation of land cover. Within this framework, the area of a category with the highest MWTP should be extended up to the point at which the MWTP of another area category exceeds the MWTP of the area category in question.

3.2 The estimation procedure

Two procedures can be applied for estimating the specified model. When a non-linear relationship or ordinality in the dependent variable needs to be taken into consideration,

⁷ The natural logarithm of zero is not defined. A small value has to be added to area shares to preserve information on area shares of zero value when taking its logarithmic form. This is standard procedure in applied econometric analysis.

ordered logit can be used. However, this requires averaging the marginal effects to calculate the MWTPs, which is open to criticism. Ordinary Least Squares (OLS) can be applied when error terms are adjusted for heteroscedasticity, which may be less accurate due to the linearity assumption. Ferrer-i-Carbonell and Frijters (2004) have shown that assuming ordinality or cardinality of the dependent variable makes little difference in a subjective well-being framework. We thus use OLS in estimating the model for greater ease of interpretation.⁸

Two issues need to be addressed when estimating the specified model. First, the number of individuals in the sample compared to the population size at the NUTS 2 level varies across regions. For this reason, we use weights of the population of the NUTS 2 regions relative to the sample size for the NUTS 2 region throughout the analysis. Second, we include information on different levels of aggregation in the same regression. In particular, data at the individual level is combined with information at the NUTS 2 level. As a result, correlation within groups can cause standard errors to be too small, and this may lead to an over-rejection of the null hypothesis. For this reason, clustering is applied at the NUTS 2 level, which relaxes the assumption that observations are independent and adjusts standard errors for intra-regional correlation accordingly (see Moulton 1990). With this procedure, heteroscedasticity-robust standard errors are obtained.

3.3 The data

3.3.1 Socio-economic characteristics

For the empirical analysis, data on individual life satisfaction plus information on demographic and socio-economic characteristics and NUTS 2 classifications are taken from the second and most recent European Quality of Life Survey (EQLS).⁹ The participants came from 31 European countries (the EU 27 Member States plus Norway, Turkey, Croatia, and the Former Yugoslav Republic of Macedonia). The interviews were carried out in 2007, with a total of 35,634 observations involving persons aged 18 and older.¹⁰

In the EQLS, information on life satisfaction (the dependent variable) is obtained by asking individuals the following question: “*All things considered, how satisfied would you say you*

⁸ For a robustness check, ordered logit has also been applied. As expected, the results are not affected.

⁹ The EQLS survey can be found on the Eurofound website: <http://www.eurofound.europa.eu/>. The principal investigator was the European Foundation for the Improvement of Living and Working Conditions. Data Collector: TNS Opinion. Sponsor: European Foundation for the Improvement of Living and Working Conditions. Distribution by UK Data Archive, University of Essex, Colchester, October 2009 (SN: 6299).

¹⁰ The number of observations per country varies between 1,000 and 2,000.

are with your life these days?”. Respondents can choose from an ordinal scale of 1 to 10, where 1 means very dissatisfied and 10 means very satisfied.

The explanatory variables at the individual level include demographic and socio-economic characteristics from the EQLS that have been found in previous studies to have an impact on subjective well-being (net household income (after tax), citizenship, age, number of people living in household, number of children, gender, marital status, employment status, residential area, education level, attendance of religious services, and health status; see Dolan et al. 2008). In contrast to other household surveys on the European level, such as the European Social Survey (ESS) or the European Value Study (EVS), which only provide ranges of household income,¹¹ the EQLS provides exact figures on net household income as reported by individuals. Studies employing these other datasets use midpoints as an indicator (see e.g. Stutzer 2004 or Ferreira and Moro 2010), a less accurate measure for household income. We apply equivalence scales on household income to account for the fact that the needs of a household grow with additional household members, albeit not proportionally (due to economies of scale in consumption). Following the modified OECD scale, we assign 1 to the first person in the household, 0.5 to every other person aged 14 and older, and 0.3 to all children under the age of 14. Net household income is then divided by the sum of these values, resulting in needs-adjusted net household income (see Atkinson and Bourguignon 2000). The advantage of using equivalence scales is that the effects of marginal changes in equivalent income can be interpreted on a hypothetical per-person basis.

For Croatia we were unable to allocate the EQLS regional classification to existing NUTS 2 regions. Accordingly, Croatia is excluded from the sample. Other observations have been dropped for miscellaneous reasons (usually failure of respondents to provide answers to specific questions).¹² In total, the data consist of 18,874 observations across 283 NUTS 2 regions in 30 different countries.¹³ Summary statistics can be found in Appendix A.1.

¹¹ The ESS can be found at: <http://ess.nsd.uib.no/>; the EVS is available at: <http://www.europeanvaluesstudy.eu/>.

¹² 99.54 % of individuals provide information on life satisfaction, so selection problems are not an issue in our analysis.

¹³ NUTS 2 regions in northern countries such as Norway, Finland, or Ireland are quite large. For the whole sample we tested different specifications by in- and excluding specific northern regions. We find that results for the whole sample are not affected. We think that including northern regions in the whole sample, representing northern regions as a sub-sample in their own right, and discussing issues related to large NUTS 2 regions is a more transparent way of going about things than excluding northern regions a priori.

3.3.2 Geographic and climatic characteristics

In order to prevent omitted variable bias, we include standard geographic and climatic characteristics in the analysis. The set of geographical variables used in the analysis is obtained from different sources. Income information from the EQLS is used to calculate median equivalent net household income for NUTS 2 regions. Population density in the NUTS 2 regions is taken from Eurostat.¹⁴ Information on longitude and latitude at the center of the NUTS 2 regions is calculated and also included in the analysis. Latitude is used to capture variation in sunlight over the annual cycle, while the elevation variable controls for differences in temperature at various regional altitudes. Finally, a coastline dummy is included in the analysis as a further control variable.

Vegetation on natural land areas may to some extent be determined by climate, which is why it is important to control for climate characteristics in the analysis. We derive climate data from New et al. (2000).¹⁵ This dataset contains 10-minute latitude/longitude data for the mean monthly surface climate averaged from 1961 to 1990 over global land areas. With this information, monthly averages are calculated for each NUTS 2 region. Our dataset includes information on mean temperature in the hottest month, mean temperature in the coldest month, and the annual mean from average monthly precipitation. These variables are chosen in accordance with the most representative findings in the literature (see e.g. Maddison and Bigano 2003, Rehdanz and Maddison 2005, Rehdanz and Maddison 2009 or Moro et al. 2008).

3.3.3 Land cover characteristics

To measure land cover characteristics, we collect information on the share of different land cover categories in the total area of the NUTS 2 regions (in percent) from the Coordination of Information on the Environment (CORINE) Land Cover database. It provides information on area cover for 44 land-cover categories in a raster format of 100 m resolution for European countries in 2006.¹⁶ We assume that shares of land cover did not change between 2006 and 2007, the reference year for the other data. As information on Great Britain and Greece is not available for the year 2006, shares of area categories for these countries were calculated from

¹⁴ See <http://epp.eurostat.ec.europa.eu>.

¹⁵ See <http://www.cru.uea.ac.uk/cru/data/hrg/>.

¹⁶ The CORINE Land Cover data is provided by the European Environment Agency: <http://dataservice.eea.europa.eu>.

CORINE Land Cover data referring to 2000.¹⁷ The category reporting unclassified areas (on average less than 0.022 percent of a NUTS 2 region) is left out of account in our analysis.

The availability of consistent low-resolution data on land cover across countries is limited. In Europe, for example, data at the national or regional level is generally compiled by individual public institutions. The CORINE Land Cover project aims at consolidating this information to provide a harmonized database for European land cover. To our knowledge, it is the only database available on a European scale.

In our analysis, information on land area covered with different land cover types is aggregated in two ways. First, data from the CORINE Land Cover database is aggregated to the NUTS 2 level. Second, individual land cover categories are aggregated. Due to the large number of land cover categories we have experimented with two different levels of aggregation. An initial set of information includes the following information on shares of land cover: (1) artificial surfaces, (2) agricultural areas, pasture and agroforestry and agricultural areas with significant natural areas, (3) forest and semi-natural areas, (4) wetlands, and (5) areas covered with water. Another specification of land cover shares is calculated for more disaggregated categories, i.e. (1) urban, industrial, and commercial areas, (2) road, rail, port areas, and airports, (3) mineral extraction sites, dumping sites, and construction sites, (4) green urban areas, sport and leisure facilities, (5) agricultural land, (6) pasture land, (7) agroforestry areas and agricultural areas with significant natural areas, (8) natural forests, (9) natural grassland and scrubland, (10) areas with little or no vegetation, (11) wetlands (including inland and maritime wetlands), and (12) areas covered with water (including inland and marine waters).¹⁸ To facilitate interpretation, area categories are classified either as artificial or as natural areas, the latter combining both cultivated and natural land cover. More detailed information on area categories can be found in Appendix A.2.

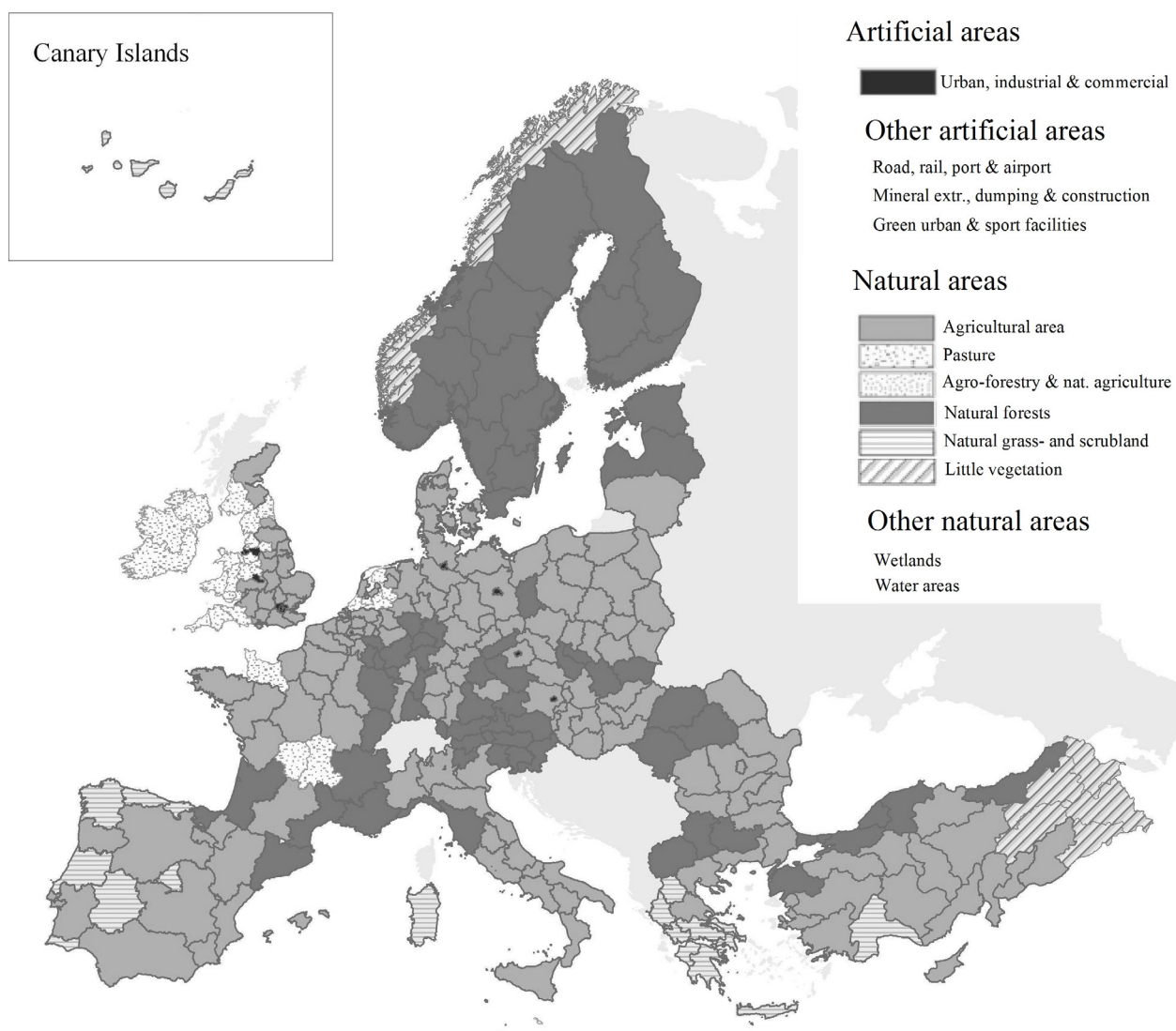
When analyzing area category shares, it is important to note that an increase in one particular area category always implies a decrease in another area category. Since artificial areas can be considered more or less sealed, we assume that an increase in a land cover category takes place at the expense of a natural category, in our case areas covered with water. This category is omitted from the analysis.¹⁹

¹⁷ Sensitivity analyses revealed that results do not change when Great Britain and Greece are excluded from the sample.

¹⁸ Generally, correlation coefficients between area categories are relatively low.

¹⁹ Sensitivity analyses reveal that marginal changes in water areas are least valued by households and thus are chosen as a reference area category in this study. This does not, of course, imply that water areas in general are of little value. Our analysis, however, follows the literature on economic impact analyses investigating values

Figure 1: Most prevalent area categories in NUTS 2 regions



Source: Own calculations. Some NUTS 2 regions are combined according to allocation by the EQLS. Natural areas combine cultivated and natural areas.

Land cover in Europe is heterogeneous (see Figure 1), which is why analyzing the effects of land cover on well-being for Europe as a whole may lead to difficulties in the interpretation of effects. Concerning the shares of land cover at the NUTS 2 level, forest is most prevalent in northern countries such as Sweden, while agricultural areas are dominant notably in central Europe. Pasture is most prevalent in the UK, Ireland, France, Belgium, and the Netherlands. Other natural area categories such as natural grass- and scrubland are prevalent only in southern countries such as Spain or Greece. Areas with little vegetation are most common in Turkey and also in Norway. To account for heterogeneity of land cover across Europe, sub-

accorded to region- and context-specific marginal changes to land cover (see Lant et al. 2004 for a discussion on this issue). Finally, it needs to be noted that the extent to which one area category can be substituted for by another is limited depending on region and area category. This issue becomes important when looking at non-marginal changes.

sample analyses are conducted for four European sub-regions: northern, central, southwestern and southeastern.²⁰ The sub-samples for Europe are described in Appendix A.3.

4. Results

4.1 Estimation results for Europe

The results of the econometric analysis of four different models for the whole sample are presented in Table 1. These models differ according to the specification of land cover characteristics. OLS estimation is applied. Robust t-statistics, which assume clustering at the level of NUTS 2 regions, are reported throughout the paper.

The impacts of demographic and socio-economic characteristics on well-being (Model 1) are similar to those typically found in the literature (see Dolan et al. 2008). We find that income and the number of people living in a household have a significant and positive effect on well-being. The results also indicate a significant U-shaped relationship between age and well-being. Furthermore, being a student positively affects subjective well-being, while unemployment has a negative effect. In line with our expectations, long-term unemployment has a stronger effect than short-term. As established in earlier studies, good health and religious faith positively contribute to subjective well-being. While the positive impact on subjective well-being increases with an increase in health status, the positive impact of “every-day” attendance of religious services is lower than “more than once a week” attendance. Furthermore, lower levels of education lead to a significant decrease in subjective well-being. Living in a village or a town has a significantly positive effect on well-being compared to living in a city, while the effect of living in a town is larger in terms of magnitude.

The other three specifications expand the first model by incorporating regional information at the NUTS 2 level. In Model 2 we find that the mean temperature in the hottest month has an inverse U-shaped impact on well-being, which is in line with findings in the literature (see e.g. Rehdanz and Maddison 2005). Mean temperature in the hottest month and its squared term are jointly significant at the 10 percent level ($F(2,282) = 2.52$), while mean temperature

²⁰ We experimented with different specifications for European sub-regions, among them the United Nations Geoscheme (UNSD 2013), which divides Europe into four regions, i.e. northern, western, eastern, and southern Europe. However, since variation in latitude for southern Europe is quite large and land cover heterogeneous, we decided to split western, eastern, and southern Europe into central Europe, southwestern Europe, and southeastern Europe, which are closely related to the definitions of European regions proposed by Germany’s Permanent Committee for Geographical Names (StAGN).

Table 1: Estimation results of different model specifications

	Model 1	Model 2	Model 3	Model 4
Life satisfaction	-	linear	linear	nonlinear
	OLS	OLS	OLS	OLS
<i>Socio-economic variables</i>				
Log equivalent income	0.5341 *** (7.11)	0.5472 *** (7.95)	0.5410 *** (7.91)	0.5425 *** (8.00)
Male	-0.0396 (-0.87)	-0.0539 (-1.21)	-0.0527 (-1.18)	-0.0515 (-1.15)
Citizen	0.2986 * (1.86)	0.2273 (1.48)	0.2398 (1.58)	0.2500 (1.65)
Age	-0.0466 *** (-4.82)	-0.0458 *** (-4.86)	-0.0460 *** (-4.87)	-0.0455 *** (-4.79)
Age ²	0.0006 *** (6.57)	0.0006 *** (6.65)	0.0006 *** (6.65)	0.0006 *** (6.53)
People	0.0672 ** (2.42)	0.0680 *** (2.67)	0.0677 *** (2.66)	0.0659 ** (2.56)
Children	0.0060 (0.26)	-0.0020 (-0.09)	-0.0006 (-0.03)	-0.0015 (-0.07)
Married	0.4596 *** (5.23)	0.4696 *** (5.54)	0.4636 *** (5.55)	0.4610 *** (5.55)
Divorced	-0.1564 (-1.61)	-0.1361 (-1.41)	-0.1426 (-1.48)	-0.1431 (-1.49)
Widowed	-0.0130 (-0.12)	0.0097 (0.09)	0.0054 (0.05)	0.0032 (0.03)
Employed	0.1567 (0.73)	0.1129 (0.53)	0.0885 (0.42)	0.1226 (0.57)
Childcare	0.3176 (1.14)	0.3086 (1.13)	0.2613 (0.97)	0.2848 (1.05)
Family business	-0.1628 (-0.42)	-0.1727 (-0.46)	-0.1962 (-0.52)	-0.1361 (-0.36)
Short-time unemployed	-0.5358 * (-1.91)	-0.5746 ** (-2.08)	-0.6013 ** (-2.16)	-0.5630 ** (-2.03)
Long-time unemployed	-0.8803 *** (-3.16)	-0.9553 *** (-3.49)	-0.9669 *** (-3.58)	-0.9604 *** (-3.56)
Disabled	0.0586 (0.21)	-0.0384 (-0.14)	-0.0794 (-0.29)	-0.0534 (-0.19)
Retired	0.3198 (1.38)	0.2559 (1.13)	0.2320 (1.03)	0.2673 (1.18)
Homemaker	0.3967 * (1.67)	0.2861 (1.21)	0.2636 (1.11)	0.3012 (1.27)
Student	0.7931 *** (3.50)	0.7477 *** (3.31)	0.7242 *** (3.22)	0.7489 *** (3.29)
Educ. level 0 (lowest)	-0.2755 (-1.40)	-0.3381 * (-1.73)	-0.3326 * (-1.72)	-0.3215 * (-1.66)
Educ. level 1	-0.4319 *** (-2.97)	-0.4893 *** (-3.27)	-0.4925 *** (-3.36)	-0.4660 *** (-3.17)
Educ. level 2	-0.2614 * (-1.75)	-0.3061 ** (-2.00)	-0.3091 ** (-2.06)	-0.2805 * (-1.86)
Educ. level 3	-0.2620 * (-1.97)	-0.3140 ** (-2.27)	-0.3195 ** (-2.38)	-0.2903 ** (-2.15)
Educ. level 4	0.0118 (0.08)	-0.0194 (-0.13)	-0.0345 (-0.23)	-0.0002 (0.00)
Educ. level 5	-0.1218 (-0.94)	-0.1508 (-1.13)	-0.1480 (-1.13)	-0.1232 (-0.94)
Bad health	1.0043 *** (5.00)	0.9621 *** (5.06)	0.9615 *** (5.08)	0.9624 *** (5.15)
Fair health	1.8859 *** (9.18)	1.8397 *** (9.37)	1.8407 *** (9.37)	1.8389 *** (9.50)
Good health	2.3582 *** (11.60)	2.3043 *** (11.76)	2.3062 *** (11.83)	2.3034 *** (11.97)
Very good health	2.8592 *** (13.28)	2.7909 *** (13.58)	2.7980 *** (13.78)	2.7896 *** (13.88)
Rel. serv.: < once a year	-0.0039 (-0.05)	-0.0070 (-0.09)	-0.0037 (-0.05)	-0.0002 (0.00)
Rel. serv.: once a year	0.0613 (0.56)	0.0530 (0.50)	0.0526 (0.50)	0.0620 (0.58)
Rel. serv.: few times a year	0.1470 ** (2.06)	0.1271 * (1.87)	0.1298 * (1.94)	0.1325 * (1.96)
Rel. serv.: once or twice per month	0.2726 *** (2.74)	0.2333 ** (2.34)	0.2395 ** (2.41)	0.2439 ** (2.40)
Rel. serv.: once a week	0.4263 *** (5.31)	0.3966 *** (5.11)	0.4020 *** (5.28)	0.4022 *** (5.08)
Rel. serv.: > once a week	0.6056 *** (4.50)	0.5212 *** (3.56)	0.5269 *** (3.61)	0.5274 *** (3.57)
Rel. serv.: every day	0.4341 ** (2.19)	0.3776 ** (2.00)	0.3953 ** (2.19)	0.3847 ** (2.08)

Table 1 (continued): Estimation results of different model specifications

	Model 1	Model 2	Model 3	Model 4
	-	linear	linear	nonlinear
Life satisfaction	OLS	OLS	OLS	OLS
Countryside	0.0308 (0.27)	-0.0205 (-0.18)	0.0099 (0.09)	0.0103 (0.09)
Village	0.1659 ** (2.12)	0.1087 (1.39)	0.1277 (1.61)	0.1416 * (1.79)
Town	0.1755 ** (2.08)	0.1070 (1.26)	0.1188 (1.41)	0.1376 * (1.66)
<i>Geographical variables</i>				
Median equivalent income of NUTS 2 region		-0.0001 (-0.77)	-0.0001 (-0.71)	-0.0002 (-1.08)
Population density		0.0001 (0.85)	0.0000 (-0.07)	0.0001 (1.58)
Longitude		-0.0274 (-1.48)	-0.0232 (-1.25)	-0.0215 (-1.20)
Latitude		-0.0528 (-0.99)	-0.0758 (-1.48)	-0.0560 (-1.08)
Avg. elevation		0.0003 (0.71)	0.0001 (0.16)	0.0004 (0.79)
Coastline		0.1652 (1.52)	0.2284 ** (2.24)	0.1347 (1.12)
<i>Climate variables</i>				
Mean temperature of coldest month		-0.0080 (-0.17)	-0.0350 (-0.75)	-0.0022 (-0.05)
Mean temperature of coldest month squared		0.0058 ** (2.03)	0.0057 * (1.89)	0.0069 ** (2.29)
Mean temperature of hottest month		0.0713 (0.30)	0.0098 (0.04)	-0.1775 (-0.77)
Mean temperature of hottest month squared		-0.0033 (-0.65)	-0.0020 (-0.40)	0.0021 (0.42)
Annual mean of average monthly precipitation		0.0102 (0.79)	0.0090 (0.70)	0.0032 (0.26)
Annual mean of average monthly precipitation squared		-0.0001 (-0.97)	-0.0001 (-0.80)	0.0000 (-0.35)
<i>Area variables</i>				
<i>Aggregated</i>				
Artificial surfaces		0.0199 (0.75)		
Agricultural area and mixed agriculture		0.0288 (1.31)		
Forest and semi natural areas		0.0206 (0.90)		
Wetlands		0.0214 (0.70)		
<i>Disaggregated</i>				
Urban, industrial and commercial area			0.0583 ** (2.25)	-0.0239 (-0.22)
Road, rail, port and airport			0.2802 *** (2.76)	0.5840 ** (2.26)
Mine, dump and construction sites			0.2081 ** (2.16)	0.1327 (0.72)
Green urban area and sport facilities			-0.0359 (-0.88)	-0.2793 *** (-2.70)
Agricultural area			0.0578 ** (2.34)	0.3462 *** (2.71)
Agro-forestry and agriculture with natural area			0.0545 ** (2.21)	0.0312 (0.51)
Pasture			0.0678 ** (2.38)	0.1474 * (1.84)
Natural forests			0.0510 ** (1.98)	0.0847 (1.03)
Natural grass- and scrubland			0.0494 * (1.94)	-0.0613 (-0.65)
Little vegetation			0.0583 * (1.85)	0.0141 (0.14)
Wetlands			0.0513 (1.47)	0.1336 (1.09)
Constant	0.9449 (1.46)	0.8481 (0.16)	-0.3052 (-0.06)	4.5478 (0.90)
Country dummies	Yes	Yes	Yes	Yes
Observations	18,874	18,874	18,874	18,874
Adjusted R-squared	0.2533	0.2631	0.2658	0.2655
F-statistic				
<i>Socio-economic variables</i>	44.64 ***	47.66 ***	46.16 ***	46.31 ***
<i>Geographical variables</i>		2.03 *	1.62	1.62
<i>Climate variables</i>		2.74 **	2.85 **	3.1 ***
<i>Area variables</i>		2.07 *	1.93 **	1.86 **

Source: Own calculations. T-statistics in parenthesis. * indicates significant at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level.

in the coldest month and its squared term are jointly insignificant. We also find individually insignificant effects of aggregated land cover, although aggregated land cover effects are jointly significant at the 10 percent level ($F(4, 282) = 2.07$). The high level of land cover aggregation suggests that individual effects cancel each other out. In the following we disaggregate the information on land cover.

In Model 3 we disaggregate area variables and find positive effects of land cover on well-being for both artificial areas and natural areas. The effect of areas dedicated to road, rail, ports or airports and mineral extraction, dumping, and construction sites is higher than for urban, industrial, and commercial areas. For natural area categories, agro-forestry and agriculture on natural areas have the highest positive effect, while natural grass- and scrubland has the lowest positive effect. Jointly, area variables are statistically significant at the 5 percent level ($F(11, 282) = 1.93$).

Nonlinear specifications of land cover are presented in Model 4. We find that road, rail, ports, and airports have a positive effect and that green urban areas and sport facilities have a negative effect, which is in line with the findings in the linear model specification. In addition, agricultural area and agro-forestry and agriculture on natural areas have a positive effect on well-being. The effects of land cover in the nonlinear model are jointly significant at the 5 percent level ($F(11, 2812) = 1.86$).

4.2 Estimated results for European sub-regions

Due to different preferences for land cover and heterogeneity of land cover across Europe, the effects of land cover on well-being could conceivably differ by region. To account for these differences, sub-sample analyses are conducted for four European sub-regions: northern Europe, central Europe, southwestern Europe, and southeastern Europe.

Linear models and nonlinear models of the sub-samples are presented in Tables 2 and 3, respectively. The results for both linear and nonlinear models indicate that changes in equivalent net household income have a higher (lower) effect in regions with lower (higher) median equivalent income. We find a smaller positive effect of income on well-being for northern Europe and southwestern Europe than in the whole sample, while the effect is much higher for central Europe and southeastern Europe.

Table 2: Estimation results of European regions – linear model specification

	Model 5	Model 6	Model 7	Model 8
	linear	linear	linear	linear
Life satisfaction	Northern Europe	Central Europe	Southwestern Europe	Southeastern Europe
Log equivalent income	0.4977 *** (4.95)	0.8134 *** (8.04)	0.4616 *** (3.38)	0.6156 *** (4.89)
Urban, industrial and commercial area	0.0313 (0.99)	0.0693 (0.88)	0.1130 *** (3.18)	0.1146 (0.57)
Road, rail, port and airport	0.9943 ** (2.68)	0.0407 (0.20)	0.4512 (1.47)	-0.7398 (-0.90)
Mine, dump and construction sites	-0.0109 (-0.05)	-0.0143 (-0.05)	-0.0343 (-0.16)	-0.1556 (-0.49)
Green urban area and sport facilities	-0.1815 *** (-3.70)	-0.1051 * (-1.76)	-0.1503 (-0.90)	0.4763 (0.42)
Agricultural area	0.0131 (0.45)	-0.0048 (-0.08)	0.0900 ** (2.30)	0.0082 (0.06)
Agro-forestry and agriculture with natural area	0.0484 (1.07)	0.1459 * (1.68)	0.0727 * (1.69)	-0.0453 (-0.32)
Pasture	0.0016 (0.05)	0.0157 (0.27)	0.0903 ** (2.31)	-0.0353 (-0.28)
Natural forests	0.0178 (0.55)	-0.0146 (-0.24)	0.0907 ** (2.35)	-0.0025 (-0.02)
Natural grass- and scrubland	-0.0365 (-0.92)	-0.0710 (-0.72)	0.0880 ** (2.22)	0.0377 (0.27)
Little vegetation	-0.0144 (-0.26)	0.1592 (1.26)	0.1266 ** (2.54)	-0.0272 (-0.20)
Wetlands	-0.0278 (-0.79)	0.2739 * (1.96)	0.0930 (1.01)	-0.0153 (-0.06)
Observations	5,574	4,566	3,735	4,999
Method	OLS	OLS	OLS	OLS
Control variables	All	All	All	All
Country dummies	Yes	Yes	Yes	Yes
Adjusted R-squared	0.3712	0.2386	0.2927	0.2125
AIC	21,445.05	19,274.88	13,575.29	21,315.79
Incremental F-statistic				
Socio-demographic variables	29.14 ***	38.09 ***	31.13 ***	89.11 ***
Geographical variables	1.87 *	2.3 *	0.83	6.25 ***
Climate variables	2.73 **	0.67	3.75 ***	2.48 **
Area variables	7.71 ***	3.29 ***	2.3 **	4.06 ***

Source: Own calculations. Abbreviations: AIC=Akaike Information Criterion. T-statistics in parenthesis. * indicates significant at the 10 percent level, ** at the 5 percent level, and *** at the 1percent level.

The significance of area shares for European sub-regions varies depending on the functional form chosen. Generally, economic theory supports the notion of decreasing MRS, indicating that MWTP should depend on the current allocation of land cover. This is also supported by the Akaike Information Criterion (AIC) for all four European sub-samples, thus indicating a general preference for the nonlinear model specification.

The results for the preferred model specifications according to the AIC indicate significant effects for some land cover categories in all sub-samples (see Table 3). In Model 9 for northern Europe, we find significant effects for both artificial and natural areas. Road, rail, ports, and airports positively affect well-being, while green urban areas and sport facilities have a negative effect. In addition, agriculture/agro-forestry and agriculture on natural areas have a significant positive effect. In central Europe (Model 10), we find that an increase in

Table 3: Estimation results of European regions – nonlinear model specification

	Model 9 nonlinear	Model 10 nonlinear	Model 11 nonlinear	Model 12 nonlinear
Life satisfaction	Northern Europe	Central Europe	Southwestern Europe	Southeastern Europe
Log equivalent income	0.4951 *** (4.92)	0.8001 *** (7.89)	0.4616 *** (3.37)	0.6061 *** (4.88)
Urban, industrial and commercial area	-0.0575 (-0.19)	0.6667 * (1.67)	0.0588 (0.35)	-0.2238 (-0.67)
Road, rail, port and airport	0.9672 * (1.79)	-0.0293 (-0.05)	0.2064 (0.56)	0.1457 (0.15)
Mine, dump and construction sites	0.0803 (0.17)	-0.2745 (-0.64)	0.1721 (0.42)	-1.2549 ** (-2.62)
Green urban area and sport facilities	-0.6865 ** (-2.48)	-0.3163 ** (-2.10)	-0.4793 (-1.46)	1.1263 (0.72)
Agricultural area	0.6355 *** (4.55)	1.1790 (1.59)	0.1476 (1.32)	1.3008 * (2.00)
Agro-forestry and agriculture with natural area	0.7651 *** (4.46)	0.4863 (1.39)	0.0126 (0.11)	-0.3082 (-1.59)
Pasture	0.1439 (0.71)	0.4474 ** (2.47)	0.1666 * (1.96)	-0.4063 (-1.53)
Natural forests	-0.1831 (-0.76)	0.4177 (1.03)	0.1886 (1.56)	0.3500 (1.48)
Natural grass- and scrubland	-0.2914 (-1.49)	0.2496 (0.83)	-0.0466 (-0.46)	0.7406 (1.45)
Little vegetation	-0.3397 (-0.96)	0.6655 (0.85)	0.3056 *** (2.84)	-0.8432 *** (-2.77)
Wetlands	0.0606 (0.35)	0.5578 ** (2.31)	-0.2009 (-1.17)	0.0190 (0.12)
Observations	5,574	4,566	3,735	4,999
Method	OLS	OLS	OLS	OLS
Control variables	All	All	All	All
Country dummies	Yes	Yes	Yes	Yes
Adjusted R-squared	0.3735	0.2401	0.2931	0.2165
AIC	21,424.94	19,266.34	13,573.24	21,290.66
Incremental F-statistic				
Socio-demographic variables	33.87 ***	38.70 ***	30.73 ***	102.22 ***
Geographical variables	4.7 ***	1.90 *	1.27	5.06 ***
Climate variables	1.76	1.30	6.03 ***	1.70
Area variables	5.74 ***	3.92 ***	1.99 **	2.45 **

Source: Own calculations. Abbreviations: AIC=Akaike Information Criterion. T-statistics in parenthesis. * indicates significant at the 10 percent level, ** at the 5 percent level and *** at the 1percent level.

urban, industrial, and commercial areas has a positive impact on well-being, while green urban areas and sport facilities negatively affect well-being. Pasture and wetlands positively affect well-being, the latter more than the former. For southwestern Europe (Model 11), we find a significant positive effect for areas with little vegetation and pasture, the latter making more of a difference than the former. By contrast, Model 12 for southeastern Europe displays green urban areas and sport facilities plus areas with little vegetation as having a negative effect. Only agricultural areas positively affect well-being.

4.3 Marginal willingness-to-pay estimates for European sub-regions

Implicit MWTPs for a 1-percent increase in each area category are calculated based on formulas (2) and (3) above for the average NUTS 2 region. Two important issues arise. First,

MWTPs for a 1-percent increase in land area differ in terms of actual square kilometers, making MWTPs incomparable. To provide a reasonable interpretation of MWTP estimates, MWTPs for a 1 km² increase in each area category are derived for the average NUTS 2 region in the sample. These can be obtained by dividing the average implicit MWTP for a 1-percent increase, as given in equations (2) or (3), by the average change to the total area of the NUTS 2 regions in km² equal to a 1-percent increase. Second, MWTP estimates are obtained by calculating the ratio of two normally distributed coefficients - the land cover and the income coefficient - with non-zero correlation. Consequently, the variance of the ratio depends on the covariance of the coefficients, which is unknown. Bootstrapping provides a solution. It involves approximating the relevant sampling distribution by generating many samples from an artificial model to mimic the data-generating process assumed to produce the actual data (see Davidson and Hinkley 1997).²¹ Standard errors and t-statistics for MWTP estimates are calculated from bootstrap distributions with n=1,999 bootstrap runs.

The results of the MWTP estimates for each of the four European sub-samples are presented in Table 4. The results for the preferred nonlinear model specifications according to the AIC indicate major preference differences for land cover categories between sub-samples. In Model 6 for northern Europe, MWTP for an increase of agro-forestry and agriculture on natural areas by 1 km² evaluated at the median equivalent net income of 13,714 euros is highest at 3.36 euros, while it is much lower for agricultural areas (only 0.65 euros). In Model 10 for central Europe, a person's annual implicit MWTP evaluated at the median equivalent income of 5,397 euros for an increase of natural areas by 1 km² lies between 0.03 euros for natural forests and 69.96 euros for wetlands. In Model 11 for southwestern Europe, little vegetation is the only category with a significant MWTP estimate of 9.50 euros evaluated at a median equivalent net income of 13,200 euros. In Model 12 for southeastern Europe, the MWTP estimates for mine, dumping, and construction sites and areas with little vegetation are negative, indicating preferences for increasing areas covered with water at the expense of these area categories. The MWTP estimate (-222.17 euros) evaluated at a median income of 2,806 euros for mine, dumping, and construction sites is much higher than the MWTP estimate of -0.26 euros for areas with little vegetation.

²¹ Bootstrapping comes in two stages. First, basic regression estimates are obtained by OLS. After that, a new matrix of error terms is obtained by resampling the residuals, which are added to the predicted values of the dependent variable. The method used for sampling the residuals is the resampling with replacement method. The estimated coefficients of the regression with the new dependent variables constitute the bootstrap estimates. This procedure is repeated n times. For more information on bootstrapping, see Davidson and Hinkley (1997).

Table 4: Implicit marginal willingness-to-pay per person per year

Marginal change of 1 km ²	Northern Europe			Central Europe			Southwestern Europe			Southeastern Europe		
	Area share (in %)	MWTP in EURO (2007)		Area share (in %)	MWTP in EURO (2007)		Area share (in %)	MWTP in EURO (2007)		Area share (in %)	MWTP in EURO (2007)	
		Model 5 linear	Model 9 nonlinear		Model 6 linear	Model 10 nonlinear		Model 7 linear	Model 11 nonlinear		Model 8 linear	Model 12 nonlinear
<i>Median annual equivalent income per person</i>	13,714			5,397			13,200			2,806		
Urban, industrial and commercial area	1.90	3.36 (0.81)	-1.73 (-0.14)	5.43	0.89 (1.03)	0.14 ** (2.41)	3.82	5.79 ** (2.23)	0.67 (0.28)	2.53	1.56 (0.50)	-0.99 (-0.51)
Road, rail, port and airport	0.09	2033.16 (1.41)	1799.18 (0.95)	0.15	18.18 (0.24)	15.75 (-0.07)	0.16	514.37 (1.21)	182.93 (0.40)	0.07	-369.74 (-0.65)	77.36 (0.10)
Mine, dump and construction sites	0.10	-15.23 (-0.02)	148.32 (0.10)	0.24	-3.42 (-0.06)	-63.17 (-0.77)	0.24	-21.54 (-0.10)	113.42 (0.34)	0.18	-35.43 (-0.36)	-222.17 ** (-2.04)
Green urban area and sport facilities	0.32	-107.56 * (-1.74)	-310.55 (-1.57)	0.57	-12.58 (-1.52)	-24.49 ** (-2.12)	0.20	-139.28 (-0.60)	-382.26 (-0.98)	0.06	281.70 (0.41)	628.97 (0.63)
Agricultural area	13.12	0.21 (0.37)	0.65 ** (2.04)	44.45	-0.01 (-0.08)	0.04 *** (3.52)	40.50	0.43 * (1.84)	0.02 (0.89)	33.19	0.01 (0.04)	0.04 (1.52)
Agro-forestry and agriculture with natural area	6.09	1.55 (0.85)	3.36 ** (2.07)	9.72	-1.04 * (1.85)	0.32 * (1.89)	7.45	1.90 (1.36)	0.04 (0.12)	3.75	-0.45 (-0.30)	-0.62 (-0.78)
Pasture	3.27	0.19 (0.09)	1.96 (0.51)	3.79	0.30 (0.29)	1.73 *** (2.94)	6.88	2.55 * (1.88)	0.60 (1.37)	8.74	-0.16 (-0.25)	-0.18 (-1.43)
Natural forests	40.78	0.09 (0.43)	-0.02 (-0.50)	30.64	-0.03 (-0.24)	0.03 * (1.74)	22.56	0.78 * (1.90)	0.07 (1.27)	20.87	-0.01 (-0.03)	0.00 (1.10)
Natural grass- and scrubland	14.29	-0.46 (-0.56)	-0.25 (-0.92)	2.64	-1.87 (-1.00)	1.79 (1.08)	14.85	1.15 * (1.81)	-0.04 (-0.36)	18.95	0.07 (0.22)	0.00 (1.24)
Little vegetation	7.57	-0.31 (-0.16)	-0.98 (-0.73)	0.69	15.87 * (1.71)	39.37 * (1.76)	2.07	11.99 ** (2.22)	9.50 * (1.80)	9.94	-0.11 (-0.18)	-0.29 ** (-2.08)
Wetlands	5.73	-0.69 (-0.38)	0.21 (0.16)	0.41	43.31 * (1.70)	69.96 *** (2.37)	0.30	61.07 (0.69)	-84.90 (-0.72)	0.52	-0.65 (-0.04)	-0.56 (-0.05)
Preferred according to AIC		√			√			√			√	

Source: Own calculations. Area Shares for European Regions are calculated based on NUTS 2 information from the sample. Abbreviations: AIC=Akaike Information Criterion. T-statistics in parentheses are obtained by bootstrap with n=1,999. * indicates significant at the 10 percent level, ** at the 5 percent level, and *** at the 1percent level. 1 km² is equal to 100 ha. ^a Natural Areas combine cultivated and natural area categories.

Our findings reveal that except for southeastern Europe most MWTP values for increases in natural areas are positive in the preferred nonlinear model specifications but with large differences in magnitude. Moreover, MWTP values in each sub-region tend to be higher for those land cover categories with a low share of total area and lower for those land cover categories with a higher share. In central Europe, people are willing to pay the highest amount for an increase in natural land covered with wetlands, which is scarce in this region. The MWTP for natural forest is lowest, as it is much more common. This squares with economic theory. The WTP is higher for an increase in scarce environmental amenities than for those that are more plentiful, indicating preferences for “balanced” rather than “extreme” allocations of land area to land cover categories.

However, the preference structure for natural areas suggested by our estimates may not be driven by area availability alone. The explanation for this is that scarcity is not the only factor influencing households’ WTP. Other factors such as distance, quality, composition, size of individual parcels of area types, etc. are important as well. For example, areas with little vegetation in central Europe may generate a relatively high MWTP due to the fact that they are often located in mountain areas, where opportunities for recreational activities such as hiking or skiing are numerous. Wetlands (which have a slightly higher MWTP) may provide fewer opportunities for recreation, but their value is high in terms both of beautiful scenery and biodiversity.

A number of issues need to be addressed in connection with the magnitude and sign of the effects of different artificial areas on life satisfaction. First, the negative impact of mining, dumping, and construction sites, as found for southeastern Europe, is fully in line with our expectations. Living close to dumping or construction sites is likely to have a negative effect on well-being compared to living close to an water (the excluded category). However, the effect is quite large, and this also leads to large MWTP estimates. Calculating artificial and natural area shares based on total artificial and total natural area respectively might resolve this to some extent. In addition, controlling for commuting activities or distances to urban centers and accounting for regional prosperity by considering purchasing power or unemployment may have an effect on the landscape amenity of artificial areas. Including median equivalent net income from the household survey for each NUTS 2 region, as in our analysis, seems an inadequate measure. Unfortunately, other European-level information on NUTS 2 regions is incomplete. In short, more detailed analysis focusing on artificial areas would be required, which is beyond the scope of this paper. Second, for green urban areas

(e.g. parks) one would expect to find a positive impact on well-being. The benefits provided by expanses of water (the excluded category) seem to be higher, apparently winning out over the benefits from green urban areas. However, for most specifications the coefficient estimated is insignificant. Information on the location of an individual and the characteristics (quality, etc.) of the green urban areas and sport facilities that the individual has access to would be required for a more detailed analysis of artificial landscape amenity effects.²²

5. Discussion and conclusions

To decide on policy measures, policymakers need comprehensive information on the costs and benefits to society of land conversion inducing ecosystem service loss. Existing studies provide mostly site-specific information based on stated preference methods, thereby often limiting comparability across studies due to differences in research design.

This paper extends the subjective well-being method by analyzing people's preferences for changes in land cover. This provides information on the economic value(s) of landscape amenities to society by estimating implicit MWTP values for European countries. The advantage of this approach is that it requires little in the way of research resources and can be consistently applied for many countries.

Our main findings are that natural land coverage has an effect on subjective well-being for people living in Europe, regardless of region. According to model selection measures, the nonlinear specification of land cover is preferred for all European sub-regions, which indicates decreasing MWTP estimates.

Our main conclusions are that the ordering of MWTPs is partly driven by the scarcity of the land cover categories. In other words, MWTP values tend to be higher for those land cover categories with the lowest shares and are lowest for those land cover categories with the highest shares, indicating preferences for “balanced” over “extreme” allocations of land cover. Other factors, such as distance or quality, may influence MWTP values but they cannot be explicitly controlled for in our analysis due to lack of information. This must be left to future research.

²² We conduct several sensitivity analyses related to regional classifications, including sub-sample analyses and interactions between area variables and regional classifications provided by the EQLS (living in a city, town, village, or the open countryside). However, EQLS classifications are not precise enough to allow for a differentiation between effects. A more detailed classification of areas would be needed, capturing differences between e.g. urban and rural regions.

Various other issues and limitations are worthy of note. First, the extent to which values are estimated is limited to the region an individual is living in. This assumption behind this is that the composition of natural areas close to individuals affects their well-being more immediately, while the composition of natural areas further away are less important. We thereby implicitly assume that subjective well-being is unaffected by events in neighboring locations. Analysis based on a spatial econometric approach investigating whether and to what extent spatial relationships exist must also be left to future research.

Second, instrumental variables can be applied to avoid potential inaccuracy of implicit MWTP estimates resulting from endogeneity of income. But the use of instrumental variables is not without its problems, and no consensus exists on the choice of instrumental variables. For our study, gathering information about instrumental variables on the European scale is difficult.

Third, several general issues have to be addressed regarding the specification and interpretation of natural area variables. The relationship between area variables and life satisfaction is only significant if area variables are separated into detailed and plausible categories. Otherwise, the effects will cancel each other out. In addition, the choice of a reference category (in our case water areas) determines the significance of land cover coefficients in the model, meaning that statistically significant differences between the reference category and other land cover categories exist.

Finally, the regional aggregation used in the multi-level analysis is important in uncovering the effects of land cover on subjective well-being. In our analysis, socio-economic information at the individual level is combined with information on the NUTS 2 level for European countries. Several issues arise here. First, lack of information on the exact locations of individuals and their workplaces makes it impossible to capture commuting activities or to give consideration to distances from urban or employment centers. Furthermore, other information on regional prosperity, such as purchasing power or unemployment, is not available at the NUTS 2 level. Second, countries in northern Europe such as Finland, Norway, or Ireland consist of a few NUTS 2 regions only. Considering large regions in the analysis makes it difficult to uncover preferences for land cover, which tend to be local rather than global. Third, for artificial areas the regional level still seems too aggregated to allow for a more detailed interpretation of effects. Future research at a higher level of regional disaggregation could profitably focus on the urban context.

Appendix

Appendix A.1: Summary statistics

Variable	Mean	Standard deviation	Minimum	Maximum
Life satisfaction				
Life satisfaction (1 = very dissatisfied and 10 = very satisfied)	6.8460	2.2080	1	10
Income				
Log of net household equivalent income (log of Euros)	6.3694	1.0890	1.8079	12.0238
Demographic characteristics				
Male (1 = yes, 0 = no)	0.4453	0.4970	0	1
Citizen (1 = yes, 0 = no)	0.9684	0.1749	0	1
Age (years)	50.1374	17.3616	18	97
Age squared (years ²)	2,815.1650	1,793.5750	324	9,409
Number of people living in household (1 = yes, 0 = no)	2.5706	1.4009	1	15
Number of children	1.7227	1.3675	0	13
Marital status				
Married (1 = yes, 0 = no)	0.6253	0.4841	0	1
Divorced (1 = yes, 0 = no)	0.1084	0.3108	0	1
Widowed (1 = yes, 0 = no)	0.1292	0.3355	0	1
*Never married (1 = yes, 0 = no)	0.1372	0.3440	0	1
Employment status				
Employed or self-employed (1 = yes, 0 = no)	0.4620	0.4986	0	1
Childcare (1 = yes, 0 = no)	0.0173	0.1303	0	1
Family business (1 = yes, 0 = no)	0.0035	0.0595	0	1
Short-time unemployment (1 = yes, 0 = no)	0.0188	0.1357	0	1
Long-time unemployment (1 = yes, 0 = no)	0.0306	0.1723	0	1
Disabled (1 = yes, 0 = no)	0.0276	0.1638	0	1
Retired (1 = yes, 0 = no)	0.3152	0.4646	0	1
Homemaker (1 = yes, 0 = no)	0.0835	0.2766	0	1
Student (1 = yes, 0 = no)	0.0323	0.1767	0	1
*Other (1 = yes, 0 = no)	0.0092	0.0956	0	1
Education level				
Education level 0 (lowest, 1 = yes, 0 = no)	0.0276	0.1638	0	1
Education level 1 (1 = yes, 0 = no)	0.1290	0.3352	0	1
Education level 2 (1 = yes, 0 = no)	0.1821	0.3859	0	1
Education level 3 (1 = yes, 0 = no)	0.3853	0.4867	0	1
Education level 4 (1 = yes, 0 = no)	0.0803	0.2718	0	1
Education level 5 (1 = yes, 0 = no)	0.1849	0.3882	0	1
*Education level 6 (highest, 1 = yes, 0 = no)	0.0108	0.1032	0	1
Health status				
*Very bad (1 = yes, 0 = no)	0.0250	0.1560	0	1
Bad (1 = yes, 0 = no)	0.1047	0.3062	0	1
Fair (1 = yes, 0 = no)	0.2919	0.4547	0	1
Good (1 = yes, 0 = no)	0.3927	0.4884	0	1
Very good (1 = yes, 0 = no)	0.1857	0.3888	0	1
Attendance of religious services				
*Never (1 = yes, 0 = no)	0.3390	0.4734	0	1
Less than once a year (1 = yes, 0 = no)	0.0998	0.2998	0	1
Once a year (1 = yes, 0 = no)	0.0714	0.2575	0	1
A few times a year (1 = yes, 0 = no)	0.2062	0.4046	0	1
Once or twice a month (1 = yes, 0 = no)	0.0972	0.2962	0	1
Once a week (1 = yes, 0 = no)	0.1356	0.3424	0	1
More than once a week (1 = yes, 0 = no)	0.0337	0.1805	0	1
Every day (1 = yes, 0 = no)	0.0171	0.1297	0	1
Living area				
*The open country side (1 = yes, 0 = no)	0.1279	0.3340	0	1
Village (1 = yes, 0 = no)	0.3776	0.4848	0	1
Medium town (1 = yes, 0 = no)	0.2377	0.4257	0	1
City (1 = yes, 0 = no)	0.2568	0.4369	0	1
Population density on NUTS 2 level				
Population density (number of people/km ²)	288.0239	658.0490	3	9,354
Geographical information on NUTS 2 level				
Longitude (°)	16.2425	10.5931	-15.6668	43.2028
Latitude (°)	49.0317	7.5073	28.3440	68.8688
Average elevation (m)	329.5488	315.9585	-3	2,075
Coast (1 = yes, 0 = no)	0.5401	0.4984	0	1

Appendix A.1 (continued): Summary statistics

Variable	Mean	Standard deviation	Minimum	Maximum
Climate information on NUTS 2 level				
Mean temperature of the hottest month (°)	18.4377	3.3818	10.2250	29.6040
Mean temperature of the hottest month squared (°)	351.3859	133.7975	104.5506	876.3969
Mean temperature of the coldest month (°)	-0.5181	5.0958	-14.7010	14.2500
Mean temperature of the coldest month squared (°)	26.2347	37.0327	0.0005	216.1194
Annual mean of average monthly precipitation (mm)	61.3422	19.1268	26.0888	149.7065
Annual mean of average monthly precipitation squared (mm)	4128.6780	3,165.7560	680.6229	22,412.0400
Area information on NUTS 2 level (Aggregated)**				
Artificial surfaces (%)	8.1004	10.7189	0.2054	96.2197
Agricultural area and mixed agriculture (%)	47.6566	18.9687	0.0000	93.0302
Forest and semi natural areas (%)	40.2103	20.2791	1.1662	87.9202
Wetlands (%)	1.3251	2.8136	0.0000	22.5373
*Areas covered with water (%)	2.7076	3.3428	0.0146	16.8601
Area information on NUTS 2 level (Disaggregated)**				
Urban, industrial and commercial area (%)	6.8040	9.0407	0.1574	82.7979
Road, rail, port areas and airports (%)	0.3202	0.5293	0.0061	4.1778
Mineral extraction, dumping and construction sites (%)	0.2996	0.3555	0.0000	1.9805
Green urban areas and sport and leisure facilities (%)	0.6765	1.3946	0.0000	13.0596
Agricultural area (%)	33.2479	18.2140	0.0000	89.8321
Agro-forestry and agriculture with natural area (%)	6.7564	6.5321	0.0000	43.3862
Pasture land (%)	7.6523	10.2817	0.0000	71.1488
Natural forest (%)	28.2363	16.2752	0.3838	66.2891
Natural grass- and scrubland (%)	9.7792	9.9905	0.0000	46.4999
Open space with little or no vegetation (%)	2.1948	6.3253	0.0000	46.2473
Wetlands (%)	1.3251	2.8136	0.0000	22.5373
*Areas covered with water (%)	2.7076	3.3428	0.0146	16.8601
Number of observations	18,874			

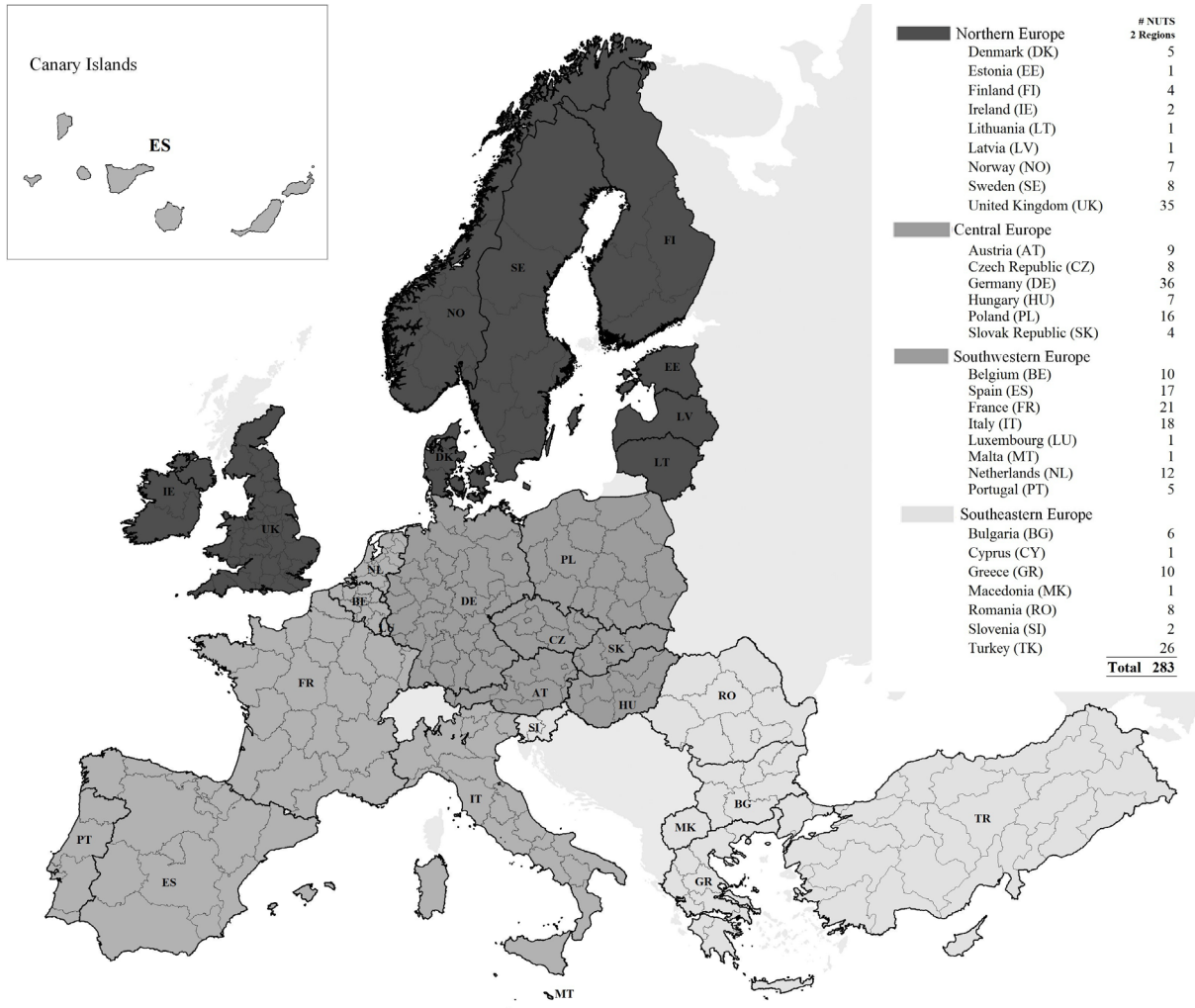
Source: Own calculations. *Reference categories in the model specifications.**Note that a minimum of zero for some areas can be found in NUTS 2 regions of capitals such as Inner London or Brussels.

Table A.2: Area aggregation

	Aggregated areas	Disaggregated areas
Artificial areas	<i>Artificial surfaces</i>	Urban, industrial and commercial area
		Road, rail, port areas and airports
		Mineral extraction, dumping and construction sites
		Green urban areas and sport and leisure facilities
Natural areas^a	<i>Agricultural area and mixed agriculture</i>	Agricultural area
		Agro-forestry and agriculture with natural area
		Pasture land
	<i>Forest and semi natural areas</i>	Natural forest
		Natural grass- and scrubland
		Areas with little vegetation
	<i>Wetlands</i>	Wetlands (including inland and maritime wetlands)
	<i>Areas covered with water</i>	Water areas (including inland and marine waters)

Source: Author's compilation. ^a Natural areas combine cultivated and natural area categories.

Figure A.3: European sub-regions



Source: Own calculations. Number of NUTS 2 Regions is based on own sample. Some NUTS 2 regions are combined according to the allocation of the EQLS. If combined, NUTS 2 regions are counted as one.

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Paper 3:
Moving to the Green*

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Abstract

This paper analyzes changes in life satisfaction as a result of moving to a greener living area. More specifically, the effects of changes in natural land cover (water areas, forest areas, agricultural areas, etc.) and urban green space on individual life satisfaction are investigated. The empirical analysis draws on highly spatially disaggregated information on individual life satisfaction in Germany. The analysis is based on an empirical life-satisfaction model derived from economic theory and accounts simultaneously for both selection bias and income endogeneity. Findings suggest that moving to a greener living environment increases life satisfaction.

Keywords: internal migration, natural land cover, urban green space, life satisfaction, Germany.

JEL codes: A12, D6, I31, R23

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1. Introduction

Social, economic, and population pressures have led to an increasing demand for new settlements both inside and outside urban areas. This may lead to a loss of the green land cover that contributes to the wellbeing of individuals. A better understanding of benefits from urban green space, such as parks in urban areas, and natural land cover such as watery areas, forest areas or agricultural areas both inside and outside urban areas is hence essential for political decision-makers aiming to improve the well-being of individuals.

Scientific studies from different disciplines have been conducted to provide information on the benefits derived from a green living environment. A number of health-related studies provide evidence of benefits for both physical and mental health (see Bowler et al. 2010 for an overview). However, there is a paucity of socio-economic studies analyzing benefits from a green living environment using individual's life satisfaction. These studies are well-suited for the provisioning of political implications in particular, as life satisfaction serves as a direct proxy for the general well-being of individuals.

Previous life-satisfaction studies on benefits from a green living environment have tended to focus on urban green space, such as parks in urban areas (see White et al. 2010, Ambrey and Fleming, 2014, Bertram and Rehdanz 2014 and Krekel et al. 2015). Extending their analysis to non-urban areas, Kopmann and Rehdanz (2013) and MacKerron and Mourato (2013) are the only existing life-satisfaction studies (also) providing comprehensive information on the benefits of natural land cover.

Irrespective of whether these studies focus on urban green space and/or on natural land cover, they are all subject to some limitations. An initial limitation might be the use of aggregated data (see Kopmann and Rehdanz, 2013), which rules out controlling for more disaggregated regional characteristics such as unemployment or urban effects. A second limitation might be the use of cross-sectional data (see Bertram and Rehdanz, 2014; Ambrey and Fleming, 2014 or Kopmann and Rehdanz, 2013), which rules out controlling for selection bias. Selection bias results from the self-selection of more satisfied individuals into regions providing greener living environments (and similarly the self-selection of less satisfied individuals into regions providing fewer green living environments) leading to reverse causality (so-called endogenous residential sorting). The use of individual fixed effects overcomes this limitation (see White et al., 2010; MacKerron and Mourato, 2013; and Krekel et al., 2015). A final limitation might be failure to restrict the analysis to the living

environment (see MacKerron and Mourato 2013), which may cause an upward bias for effects from natural land cover that are specific to recreational areas.

The aim of this paper is to account for these limitations in estimating the effects on life satisfaction of changes both in natural land cover and in urban green space in and outside urban areas, with the ultimate goal of devising monetary measures for the benefits of a greener living environment. The analysis is based on individual information for 2006, 2008, and 2010 from the German Socio-Economic Panel (GSOEP), which is restricted by the land cover data used in the analysis. Profiting from the advantages of this large panel dataset, the analysis improves upon earlier studies as follows: First, the analysis takes advantage of the GSOEP's highly spatially disaggregated information on individuals' places of residence at the municipality level, the lowest level of official territorial division in Germany.¹ Second, selection bias is ruled out by using individual fixed effects. Third, holiday periods are excluded by focusing on the living environment of individuals.

In addition to counteracting these limitations, the present study also takes one further finding into account by explicitly focusing on effects for internal (i.e. within-country) migrants only. Krekel et al. (2015) emphasize that in an individual fixed-effects setting, effects from urban green space are significant for movers only. As we saw above, individual fixed effects are however essential in accounting for selection bias. A simple explanation for the resulting insignificance of effects for non-movers is that, with individual fixed effects, only changes in variables over time (within-group variation) are used for the identification of effects. However, panel studies such as White et al. (2010), MacKerron and Mourato (2013), or Krekel et al. (2015) often use land cover from one specific year only for the whole analysis, as land cover changes tend to be small over the sample periods commonly used (maximum of 12 years). Changes in the place of residence then provide the necessary variation for the identification of effects. When estimating effects for both movers and non-movers, the significance of effects decreases (inefficiency of the estimator). To overcome this issue in the present study, effects on life satisfaction of a greener living environment are estimated for internal (within-country) migrants only. As a robustness check, effects for non-migrants and joint effects for both migrants and non-migrants will also be discussed. Unlike the above-mentioned studies, the present investigation is based on land cover data for more

¹ The average size of municipalities in our sample is 63 km² with a minimum of 1 km² and a maximum of 891 km² in 2006.

than one year (3 years). However, the empirical results will show that for non-migrants effects from changes in land cover also tend to be insignificant, this being a function of the short sample period.

The analysis is structured as follows: First, effects on life satisfaction from moving to a greener living environment are estimated for the working-age population using the specification of the empirical life satisfaction model proposed by Faßhauer and Rehdanz (2015). This specification accounts for a wide range of characteristics important for the analysis of decisions to migrate (individual socio-economic characteristics, housing costs, migration costs, housing characteristics, regional economic characteristics) and instruments income with real equivalent predicted labor earnings. In addition, we control for other environmental characteristics conceivably correlated with a green living environment and also affecting life satisfaction, such as climate characteristics and distances from sites with specific recreational values. On the basis of these empirical results, the second step is to derive conservative monetary measures for the trade-off between income and benefits of moving to a greener living environment.

The main finding of this study is that moving to a greener living environment increases life satisfaction. More specifically, benefits from moving to a living environment featuring an increase of 1 km² of water area or urban green area represent 28 percent or 13 percent of household income, respectively. The benefits from moving to a living environment featuring an increase of 1 km² of forest area or agricultural area only represent about 1 percent each of household income. This difference in benefits from different land cover types is entirely due to the scarcity of green land cover. Water areas and urban green space (forest areas and agricultural areas) are very scarce (more plentiful), which is why they are valued more (less).

The paper is structured as follows: In Section 2 we present an overview of previous research. Section 3 describes the empirical specification and the estimation method. The data set is presented in Section 4. In Section 5 empirical results are discussed. Benefits from moving to a greener living environment are monetized in Section 6. Discussions are given in Section 7. Section 8 concludes.

2. Previous Research

A number of recent studies provide insights into benefits accruing from changes in green land cover using life satisfaction as a proxy for individual well-being. In environmental life-

satisfaction studies, life satisfaction is regressed on environmental amenities (or disamenities) such as climate, air pollution, or land cover alongside socio-economic characteristics such as income. The marginal willingness-to-pay (MWTP) calculated by the trade-off between the effect of environmental amenities (or disamenities) and income then provides a monetary measure for benefits (costs) from changes in environmental amenities (or disamenities) (see Welsch and Ferreira 2015 for an overview). In the valuation of urban green space and natural land cover, studies have considered the distance from or the coverage of land-cover categories including urban green space (such as parks) or natural land cover (such as water areas, forest areas, or agricultural areas).²

Several studies find that there are positive effects from urban green space on urban life satisfaction. In a cross-section study, Ambrey and Fleming (2014) find positive effects on life satisfaction from the percentage of green space in the resident's collection district. The investigation focuses on major Australian cities and uses the Household, Income and Labour Dynamics in Australia (HILDA) survey for the year 2005 and data on green space provided by NAVIGATE Pt Ltd. for the year 2010. Bertram and Rehdanz (2014) find positive effects of green space on life satisfaction for residents in Berlin using a web survey from the year 2010 and land-use data from the European Urban Atlas (EUA) for the year 2006. To overcome selection bias, White et al. (2013) and Krekel et al. (2015) make use of panel data and apply individual fixed effects. White et al. (2010) find positive effects from urban green space using the British Household Panel Survey (BHPS) for the years between 1991 and 2008 and land-use data from the general land-use database (GLUD) for the year 2005. Similarly, Krekel et al. (2015) find positive effects of urban green space using data from the German Socio-economic Panel (GSOEP) for the years between 2000 and 2012 and land-use data from the European Urban Atlas (EUA) for the year 2006. Krekel et al. (2015) also emphasize that effects from urban green space are only significant for movers in their individual fixed-effects setting, as land cover does not change for non-movers (i.e., the latter effects are captured by individual fixed effects).

Studies extending the analysis to include natural land cover such as water areas, forest areas or agricultural areas in and outside urban areas alongside urban green space also find

² In addition to the studies summarized in the following, two further studies have been conducted: Ambrey and Fleming (2012) analyze effects of protected areas, and Ambrey and Fleming (2011) value scenic amenities. However, neither of these studies is (closely) related to the present investigation. They consider different measures than the land-cover types used in our study and will not be discussed further.

positive effects on life satisfaction. In a cross-section study based on data from the European Quality of Life Survey (EQLS) for the year 2007 and on aggregated land-use data at the NUTS 2 level from the CORINE land use database for the year 2006, Kopmann and Rehdanz (2013) find that natural land cover and urban green space are positively associated with life satisfaction for 31 European countries. The value is higher (lower) for scarce (more plentiful) land-cover categories, albeit with exceptions, which however may be due to selection bias caused by data restrictions. To overcome this limitation, MacKerron and Mourato (2013) apply individual fixed effects using data collected from daily iPhone questionnaires about people's life satisfaction combined with their actual whereabouts in the years 2010/2011 and land-use data from the UK Land Cover Map 2000. They find that natural land cover has a positive impact on life satisfaction, with marine and coastal margins and mountains, moors, and heathland providing the largest benefits. However, these estimates may be upward-biased as data restrictions make it impossible to control for effects from holiday periods.

The present study provides insights on the benefits of both urban green space and natural land cover in and outside urban areas, a focus similar to Kopmann and Rehdanz (2013) and MacKerron and Mourato (2013). In addition, the analysis is related to Krekel et al. (2015), as they also base their analysis on GSOEP data. However, Krekel et al. (2015) focus on urban areas only, using urban land-cover data from the EUA for 35 of 76 German cities. This is why they only find significant effects for urban green space and abandoned areas and not for natural land cover. The present study differs from Krekel et al. (2015) by also providing information on natural land cover outside urban areas and using spatially inclusive and comprehensive urban and non-urban land-cover data for Germany provided by the Leibniz Institute of Ecological Urban and Regional Development (IOER). Accordingly, the analysis in the present study supplies information on average benefits from green land cover that are not specific to urban areas.

Our investigation estimates benefits from urban green space and natural land cover, while overcoming several data-restriction limitations encountered in the above-mentioned studies. First, in contrast to Kopmann and Rehdanz (2013), who base their analysis on aggregated data on the NUTS 2 level for European countries, we use highly spatially disaggregated land-use data at the municipality level. Second, in contrast to other cross-section studies (see Ambrey and Fleming, 2014; Kopmann and Rehdanz, 2013; and Bertram and Rehdanz, 2014), individual fixed effects are applied to overcome selection bias. Third, in contrast to MacKerron and Mourato (2014), effects are derived for the living environment only so as to overcome bias from holiday activities. Finally, benefits from a green living environment are

derived for internal migrants (movers across the borders of municipalities) using interaction terms, which makes it possible to separate them from effects for non-migrants captured by individual fixed effects. Effects for non-migrants and joint effects for both migrants and non-migrants will also be discussed.

3. Empirical Model and Estimation Method

3.1 Empirical specification

The empirical model is an extension of the empirical life-satisfaction model proposed by Faßhauer and Rehdanz (2015), which is derived from a theoretical model of utility-maximizing individuals. Faßhauer and Rehdanz (2015) estimate an average effect for regional amenities using a simple migration dummy to capture changes in the amenity level caused by internal migration. The present study differs from Faßhauer and Rehdanz (2015) by introducing a number of specific environmental amenities and using interaction terms to separate effects for migrants and non-migrants. The empirical life-satisfaction model is then estimated as follows:

$$LS_{i,j,t} = \beta + \beta_y \ln Y_{i,t} + \beta_x X_{i,t} - \beta_h \ln R_{i,t} + \beta_d D_{i,t} + \sum_k \beta_{am,k} A_{j,k,t} + \beta_{nm} NM_{i,t} + \sum_k \beta_{anm,k} A_{j,k,t} NM_{i,t} + \mu_t + \nu_i + \varepsilon_{i,j,t}, \quad (1)$$

where $LS_{i,j,t}$ represents reported life satisfaction of individual i in region j at time t . $Y_{i,t}$ is real household-equivalent income. $X_{i,t}$ are socio-economic characteristics detailed below. $R_{i,t}$ are real housing costs per m² (=square meter) of individual i at time t . Migration costs MC are considered by $\beta_d D_{i,t}$ where $\beta_d = MC/D_{i,t}$ is the unit cost of migration and $D_{i,t}$ is the migration distance.³ $NM_{i,t}$ is a dichotomous variable, taking the value of one if an individual i does NOT migrate across regions at time t and zero otherwise. $A_{j,k,t}$ are k regional amenities in region j at time t . $A_{j,k,t} NM_{i,t}$ represents an interaction term between regional amenities and the non-migrant dummy. According to this empirical specification, benefits from migrating to a greener living environment are derived as a residual effect after separating out effects of a green environment for non-migrants as determined by the interaction terms of the non-migrant dummy and the regional amenities. The corresponding coefficient $\beta_{anm,k}$ captures effects on life satisfaction for non-migrants from changes in regional amenities. The

³ Note that for non-migrants, migration distance is *per se* zero.

coefficient $\beta_{am,k}$ then captures any remaining effects of regional amenities (i.e. effects from changes in regional amenities for migrants only) and is hence the focus of the analysis.⁴ Finally, μ_t are year-fixed effects, v_i are individual-fixed effects, and $\varepsilon_{i,j,t}$ represents the error term.

In this empirical model, as in Faßhauer and Rehdanz, (2015), a possible downward bias in the income coefficient resulting from endogeneity is also controlled for by using real equivalent predicted labor earnings as an instrument for household income (see Luechinger, 2009 and Vendrik, 2013 for earlier applications). These are obtained by regressing the natural logarithm of labor earnings provided by GSOEP for each individual on industry and occupation dummies for each year, separately for West and East Germany. The exponential of the predicted value is summed up over household members, which yields a final measure for predicted labor earnings (see Vendrik, 2013).⁵ This is important, as otherwise MWTP estimates determined by the quotient of the coefficient of the environmental amenity and the income coefficient would be overestimated. Sources of downward bias in the income coefficient result from individual efforts leading to higher earnings and positively affecting life satisfaction (see Luechinger, 2009) or measurement error for income (see Vendrik, 2013).

3.2 Estimation method

Two methods can be applied for estimating the above model, ordered logit or Ordinary Least Squares (OLS). Ordered logit accounts for a non-linear relationship or ordinality in the dependent variable. However, it requires averaging the marginal effects to calculate the effects on life satisfaction, which is open to criticism. OLS can be applied when adjusting error terms for heteroscedasticity, which may be less accurate due to the cardinality assumption. Ferrer-i-Carbonell and Frijters (2004) have shown that in life-satisfaction analyses controlling for individual fixed effects is much more important than assuming ordinality or cardinality of the dependent variable. In our analysis, OLS is used to estimate the

⁴ If there were no interaction term, β_{am} would be interpreted as the unique effect of environmental amenities on life satisfaction. But the interaction means that the effect of environmental amenities on life satisfaction is different for different values of NM. In the interaction model, the effect of environmental amenities on life satisfaction is not limited to β_{am} , but also depends on the values of β_{amm} and NM . The effect of environmental amenities in the interaction model is $\beta_{am} + \beta_{amm} * NM$. For migrants ($NM=0$) the effect of environmental amenities on life satisfaction is given by β_{am} . For Non-Migrants ($NM=1$), the effect of environmental amenities on life satisfaction is $\beta_{am} + \beta_{amm} * 1$.

⁵ Following Luechinger (2009), self-employed people in the sample are excluded before estimating labor earnings, as they tend to be more reluctant to state their income.

model for its greater ease of interpretation, and ordered logit is used for a robustness check. As expected, the results are not affected.

As people living in the same region tend to be more similar, estimating an empirical life-satisfaction model with information at the regional level raises concerns connected with the correlation of observations. In addition, intra-personal correlation can arise as individual characteristics may be correlated over time. It is important to cluster observations, which relaxes the assumption that observations are independent and adjusts standard errors accordingly (see Moulton, 1990). As the focus of the present study is explicitly on regional variables, the most conservative approach is applied, which is two-way clustering at the individual and at the regional level. Finally, to adjust for differences in the sampling design compared to the actual population, regressions are weighted by panel sampling weights provided by the GSOEP.

4. Data

Our analysis is based on the same raw dataset as the one used by Faßhauer and Rehdanz (2015). It derives from the German Socio-Economic Panel (GSOEP) and is restricted by land-cover data used in the analysis to three years: 2006, 2008, and 2010. The GSOEP is a representative longitudinal study providing socio-economic information on approximately 20,000 individuals and 10,000 households in Germany (see Wagner et al., 2007). The sample covers the working population aged 18 to 63, the latter representing the average retirement age in Germany in 2006 (DRV, 2012). Information on life satisfaction (the dependent variable) is used in the form provided by GSOEP, where it is obtained by asking individuals the following question: “*All things considered, how satisfied would you say you are with your life these days?*”. Respondents can choose from an ordinal scale of 0 to 10, where 0 means very dissatisfied and 10 means very satisfied.

To link life satisfaction to the decision to migrate, regional information on the residences of GSOEP households at municipality level is used. The municipality is the lowest level of official territorial division in Germany.⁶ Following Faßhauer and Rehdanz (2015), individuals

⁶ There are more than 12,000 municipalities in Germany with an average size of 29 km² in 2006 (*Statistisches Bundesamt*). The number changes over time. For consistency, we differentiate in the present analysis between 11,449 regions. The GSOEP, however, does not provide observations for all municipalities. Data can be accessed at: www.destatis.de.

are classified as migrants if they ‘cross’ the administrative borders of municipalities. The final sample consists of 29,901 observations (or 9,562 persons), 7,638 municipality-year combinations (or 1,496 municipalities), and 352 migrants.⁷

The analysis extends the basic empirical life-satisfaction model of Faßhauer and Rehdanz (2015) by adding regional environmental characteristics at the municipality level, which is the main focus of the present paper. More specifically, green land cover shares in percent provided by the IOER for the years 2006, 2008, and 2010 are considered.⁸ These include (1) green urban areas, (2) agricultural areas, (3) forest areas, (4) heathlands, moors, and areas with little vegetation, and (5) water areas. The analysis is based on the assumption that changes in green land cover take place at the expense of settlement and traffic areas, the land-cover category that has been excluded.⁹ Following Kopmann and Rehdanz (2013), who find that the natural logarithm of land cover shares is the preferred specification in empirical life-satisfaction models, the natural logarithm of land-cover shares is also used in the present analysis.¹⁰ This is in line with decreasing marginal benefits from changes in green land cover, as suggested by economic theory.

To control for any omitted variable bias at the regional level, further regional characteristics at the municipality level are controlled for. First, other environmental amenities (and disamenities) possibly correlated with land-cover shares are considered: (1) regional climate characteristics (standard deviation of monthly mean temperature and standard deviation of monthly mean precipitation) calculated from information provided by the German Weather Service (DWD)¹¹ and (2) distance from recreational sites (dummy for living within a 100 km radius of the coast, dummy for living within a 100 km radius of mountains) calculated using information provided by UNEP-WCMC¹² and Data and Maps by

⁷ The number of migrants (352) is slightly higher than in the final model specification of Faßhauer and Rehdanz (2015) (340). This results from excluding neighborhood characteristics in the present study. In the present paper, land-cover information is highly correlated with neighborhood characteristics, which is why neighborhood characteristics are omitted. Given that the number of migrants is small in our sample, this has the advantage of increasing the number of migrants.

⁸ Data from the IOER can be accessed at: www.ioer-monitor.de.

⁹ Note that the choice of excluded land-cover categories affects the size of effects but not the ordering.

¹⁰ Other functional forms such as the level of land-cover shares, and the level of land cover shares jointly with its squared term have been tested. The Akaike-Schwartz-Criterion (AIC) suggests that in the present study the natural logarithm is preferable to all the other specifications, much as in Kopmann and Rehdanz (2013).

¹¹ DWD data can be accessed at: www.dwd.de.

¹² For calculating the mountain dummy in the final model specification, distance from mountains is obtained with a height of at least 2500 m provided by UNEP-WCMC. However, various other distances from mountains

ESRI.¹³ (2) Several economic characteristics of the region (Euclidean distance from the nearest large city based on own calculations¹⁴, regional purchasing power and regional unemployment provided by the BBSR) are accounted for, as suggested by Faßhauer and Rehdanz (2015).

To control for omitted variable bias at the individual and the housing level, individual and housing characteristics found in Faßhauer and Rehdanz (2015) to significantly affect benefits from regional amenities are controlled for. These characteristics include a large number of socio-economic characteristics provided by the GSOEP (net household income (after tax), citizenship, age, number of persons in household, gender, marital status¹⁵, employment status, education years, and health status; see Dolan et al., 2008), housing costs per m², migration distance (Euclidean distance calculated from the coordinates of the centroids of the municipalities), housing characteristics (size, construction year, ownership, equipment, condition of the apartment/house, and environment of the apartment/house), and labor characteristics (contract length, job tenure, actual working hours and its squared term). Following Faßhauer and Rehdanz (2015), real equivalent predicted labor earnings are used for the instrumentation of income (see also Luechinger, 2009 and Vendrik, 2013). Summary statistics are provided in Appendix A.2.

5. Empirical Results

The results of the empirical analysis are presented in Table 1. They indicate that moving to a greener living environment has positive and diminishing effects on life satisfaction. More specifically, moving to a living environment with higher shares of natural land cover such as water areas, forest areas, and agricultural areas (at the expense of settlement and traffic areas) has a positive and significant effect on life satisfaction. However, moving to a greener living environment in urban environments also positively affects life satisfaction. More specifically, findings suggest a positive and significant effect on life satisfaction from moving to a living

have been tested with at least 1500 m and 1000 m without affecting our results. Data can be accessed at: http://www.unep-wcmc.org/mountains-and-tree-cover-in-mountain-regions-2002_724.html.

¹³. To calculate the distance to the coast, borders of European countries as provided by ESRI data and maps are used. See www.esri.com/data/data-maps.html.

¹⁴ Large cities are defined on the basis of BBSR structural municipality types: (1) major large cities, (2) large cities in agglomeration counties, and (3) large cities in urban counties; see Table A.1 in the Appendix.

¹⁵ To control for any effects from moving in with a partner, information on marital status (such as being married) is combined with with living or not living with a partner (see Luechinger, 2009), which would otherwise be captured in effects from changes in environmental amenities.

(1)					
Baseline Model					
Life satisfaction	Coef.	t-stat		Coef.	t-stat
<u>Changes in regional land cover characteristics for migrants</u>			<u>Changes in regional distance from recreational sites for migrants</u>		
Ln settlement and traffic	<i>Reference group</i>		Not within 100 km of coast	<i>Reference group</i>	
Ln of green urban	0,3600 *	1.95	Within 100 km distance of coast	-0,3389	-0.60
Ln agriculture	0,6215 *	1.96	Not within 100 km distance of mountains	<i>Reference group</i>	
Ln forest	0,4041 ***	2.02	Within 100 km distance of mountains	0,2660	0.52
Ln heathland, moor and little vegetation	-0,2670	-1.35	<u>Changes in socio-economic characteristics for migrants</u>		
Ln water	0,5229 **	2.43	Ln real equivalent net household income (instrumented)	1,2649 **	2.51
<u>Changes in regional economic characteristics for migrants</u>			Ln real equivalent household rents/m ²	-0,0212	-1,05
Distance from large cities	0,0172 **	2.00	<u>Effects from migration</u>		
Real purchasing power	0,0373	0,66	Migrating 'across' municipalities	<i>Reference group</i>	
Unemployment	-0,0020	-0.06	Not migrating 'across' municipalities	0,2889	0,09
<u>Changes in regional climate characteristics for migrants</u>			Migration distance	0,0160	0.15
Standard deviation of monthly mean temperature	-0,8704	-1.58	<hr/>		
Standard deviation of monthly mean precipitation	0,0234	0.55	<i>Interactions of non-migrant dummy with regional vars</i>	<i>Yes</i>	<i>Instrumentation of household income</i>
<hr/>			<i>Individual fixed effects</i>	<i>Yes</i>	<i>Number of persons</i>
<hr/>			<i>Year effects</i>	<i>Yes</i>	<i>Average observation per person</i>
<hr/>			<i>Other socio-economic and housing controls</i>	<i>Yes</i>	<i>Observations</i>
<hr/>					29.901

Tab. 1: Changes in environmental characteristics for migrants and life satisfaction for German municipalities

Source: Own calculations. The model is estimated by GMM. Robust standard errors are two-way clustered for person and municipality number. Effects of other controls are presented in Appendix A.3. Other controls include (1) socio-economic characteristics: citizenship, age, number of persons in household, gender, marital status, employment status, education years and health status, contract length, job tenure, actual working hours and its squared term and migration distance; (2) housing characteristics: Ln real equivalent housing costs per m², size, construction year, ownership, equipment, condition of the house/flat. Ln real equivalent net household income is instrumented with Ln real equivalent predicted labor earnings. T-statistics are reported. * indicates significant at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level.

environment with higher shares of green urban land cover. The effect of moving to a living environment with higher shares of heathland, moor, and little vegetation is insignificant.

Empirical findings indicate insignificant effects on life satisfaction from moving to a living environment with higher (or lower) amounts of other environmental amenities (or disamenities) next to green land cover. Effects from moving to a living environment with a less moderate climate are insignificant. Of these, the negative effect of moving to a living environment with a larger standard deviation of monthly mean temperature is, however, only just insignificant at the 10 percent level. Effects from moving to a living environment close to recreational areas such as coastal or mountain areas are also insignificant.

Only one of the effects for regional economic amenities (or disamenities) is significant. Moving to sites at longer distances from large cities has a positive effect on life satisfaction significant at the 5 percent level.¹⁶ The effect of regional real purchasing power and the effect of regional unemployment on life satisfaction are as expected; they are positive and negative, respectively, but insignificant.

Effects from all of the above-mentioned regional characteristics are insignificant for non-migrants (interaction terms between regional characteristics and the non-migrant dummy). As changes in regional characteristics during the sample period tend to be small, this is to be expected. See Appendix A.3. for the effects of regional characteristics for non-migrants.

Finally, the effects on life satisfaction of changes in socio-economic characteristics are similar to those typically found in the literature (see Faßhauer and Rehdanz, 2015). The effect of income on life satisfaction is positive and diminishing. The income effect is more than three times as large when instrumenting income with real equivalent predicted labor earnings in comparison to the income effect when not instrumenting income (1.27 in comparison to 0.33, the latter is not presented). This is slightly higher than findings in the literature, where the effect is more than twice as large (see Luechinger, 2009 and Vendrik, 2013), but this is a result of the small sample size in the present analysis. In addition, the instrument passes the under-identification test of Kleibergen-Paap rk LM statistic of 20.896 (at a significance level

¹⁶ Sensitivity analyses suggest that the positive effect of moving to a living environment at longer distances from large cities is driven by benefits from moving to suburbs. Benefits from moving to living environments at even longer distances from cities, i.e. when moving to a living environment in rural areas, tend to be smaller, but do not decrease any further with distance. This is why using a squared term of distance from cities in addition to level does not provide a more accurate specification. However, results are robust to using different functional forms of distance from large cities in the empirical model.

of 1 percent) and the weak identification test of Kleibergen-Paap rk Wald F statistic of 36.778 (compared to the conventional required value of 10). As expected, the effect of housing costs per m² on life satisfaction is negative but insignificant. Migration effects including the non-migrant dummy and migration distance are also insignificant. The effects of other socio-economic characteristics are presented in Appendix A.3.

6. Monetizing Benefits from Moving to the Green

Using estimation results for the effects on life satisfaction of moving to a greener living environment and household income, MWTPs for moving to a greener living environment can be calculated. This provides information about the income changes required to compensate for a 1-percent change in green land cover. The calculations are as follows:

$$\text{MWTP for green land cover} = - \frac{\delta Y}{\delta A} \Big|_{dLS=0} = \frac{\hat{\beta}_{am} Y_m}{\hat{\beta}_y A_m} . \quad (2)$$

Here, Y is real equivalent net household income, A the amount of environmental amenities, β_{am} the estimated parameter for environmental amenities for migrants, β_y the estimated parameter for the natural logarithm of real equivalent net household income, Y_m the median of real equivalent household income of migrants, and A_m the median amount of environmental amenities for migrants. To obtain MWTPs for a 1-km² change in the respective land cover category, the amount is then divided by the area in km² that equals 1 percent of the average size of municipalities.

MWTP estimates for green land cover derived from our analysis suggest that moving to a greener living environment provides considerable benefits for individuals. Using results from Table 1, the WTP for a 1 km² change in water area as provided by the monthly income change is largest at € 498, corresponding to 28 percent of household income. The WTP for a 1-km² change in green urban area is second largest at € 235, equivalent to 13 percent of household income. WTPs for a 1-km² change in forest area and agricultural area are lowest at € 21 and € 14, respectively, both equivalent to approximately 1 percent of household income. Common to all these MWTPs is the fact that they are significant at the 10-percent level. Given that the coefficients used to calculate the MWTPs (coefficient of green land cover and the income coefficient) are significant at even higher levels of significance (at the 5-percent level and at the 1-percent level) and that the number of migrants is small (352), this 10-percent level of

	Evaluated in terms of monthly median income of € 1,764			
	Estimate	z-value	% of income	Share in %
Water	498 *	1.66	28	1.10
Green urban	235 *	1.68	13	1.66
Forest	21 *	1.67	1	20.63
Agriculture	14 *	1.81	1	48.03

Tab. 2: MWTP estimates for changes in green land cover

Source: Own calculations. Estimates are derived from Table 1. Only significant effects are presented. Robust standard errors are two-way clustered for person and municipality number. T-statistics are obtained using the delta method. * indicates significant at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level.

significance for MWTP estimates is assumed to be sufficient evidence for the existence of effects. The MWTP for areas with little vegetation is insignificant.

Several robustness checks concerning the derivation of benefits from changes in green land cover are worthy of note. First, using changes in green land cover for migrants instead of changes for both migrants and non-migrants for the derivation of benefits from changes in green land cover considerably affects the empirical results. Findings from the empirical life-satisfaction analysis suggest that benefits from green land cover are downscaled by a factor of 0.8 when using changes in green land cover for both migrants and non-migrants (not presented) instead of changes in green land cover for migrants only. In addition, the significance of MWTPs decreases, as changes in green land cover tend to be fairly small for non-migrants.

Second, accounting for distance from large cities in the empirical model considerably affects the empirical estimates. Findings from the empirical life-satisfaction analysis suggest that the benefits of a green living environment are at least 1.25 times larger when distance from large cities is not accounted for (not presented) than estimates from the empirical model including distance from large cities. This suggests that the positive effect on life satisfaction of living outside large cities biases MWTPs for green space upwards if not accounted for.

7. Discussion

Several issues concerning the empirical estimates of benefits from changes in green land cover are worthy of discussion. First, positive MWTPs for changes in urban green areas, water areas, forest areas, and agricultural areas suggest among other things that changes in

green land cover at the expense of settlement and traffic areas provides benefits for migrants. The findings on the benefits from urban green areas are in line with the outcomes of earlier urban studies (see White et al., 2010; Ambrey and Fleming, 2014; Bertram and Rehdanz, 2013 and Krekel et al., 2015). The findings on benefits from natural land cover are in line (a) with the findings by MacKerron and Mourato (2013) in a study based on panel data and applying individual fixed effects in a similar way to the present study and (b) with Kopmann and Rehdanz (2013), who base their analysis on more aggregated cross-sectional data. However, Kopmann and Rehdanz (2013) find MWTPs with opposite signs for some urban land-cover categories in European subregions. For example, they find a positive MWTP for changes in urban, industrial, and commercial areas at the expense of water areas for Central Europe (suggesting that the MWTP for water areas at the expense of urban, industrial, and commercial areas would be negative, which is precisely the opposite to what the present study indicates). This suggests that, when analyzing urban green areas and natural land cover in and outside urban areas jointly, the estimates from cross-sections might be subject to selection bias, as individual fixed effects cannot be applied. Other reasons for differences in effects might be due to differences in the level of aggregation, regional differences in land cover types, the focus on migrants only in the present study, differences in regional boundaries, weighting of the estimation etc. The weighting of the estimation e.g. affects the outcome of the analysis. When not weighting the estimation, effects from migration are biased due to differences in the sampling design over and against the true population and benefits from environmental amenities cannot be estimated accurately (see Faßhauer and Rehdanz, 2015).

Second, the MWTP estimates presented in this study suggest that the ordering of benefits from green land cover depends entirely on the scarcity of land-cover categories. MWTPs are largest for water areas and green urban areas (€ 498 and € 235, respectively), both of which are scarce (with a median area share of 1.1 % and 1.66 %, respectively). MWTPs are lowest for forest areas and agricultural areas (€ 21 and € 14, respectively), both of which are more plentiful (with a median area share of 20.63 % and 48.03 %, respectively). The fact that the ordering of MWTPs is driven by scarcity of green land cover is also partly reflected in findings by Kopmann and Rehdanz (2013). In their study, water areas, which are very scarce, tend to be least valued (which is why it is chosen as the reference category in this study). However, for many other natural land-cover categories, ordering-by-scarcity assumption also applies in Kopmann and Rehdanz (2013).

Finally, a number of issues can be usefully addressed concerning differences between the empirical results of the present study and those presented by MacKerron and Mourato (2013). As in our study, MacKerron and Mourato (2013) find that effects of specific water areas on life satisfaction are largest. However, MacKerron and Mourato (2013) find the largest effects for marine and coastal margins only, while the effects of freshwater areas, wetlands, and floodplains are much lower. In the present analysis, robustness checks (not presented) suggest that benefits from water areas are driven by inland water and not by water in regions on the coast (interacting water areas either with a coast dummy or with a distance from the coast of less than 10 km). Furthermore, MacKerron and Mourato (2013) find that effects of mountains, heathlands, and moors on life satisfaction are second largest. Robustness checks from the empirical model of the present study (not presented) suggest that benefits from heathlands, moors, and areas with little vegetation in mountain regions are negative (when analyzing the effect of heathland, moor, and area with little vegetation multiplied by a distance of less than 30 km (10 km) from mountains with more than 1,500 meters (1,000 meters height). However, further robustness checks suggest positive effects from moving closer to mountain regions in general (when considering distance from mountains as a further control) (results are not presented).¹⁷ These findings suggest that holiday activities, which MacKerron and Mourato (2013) could not exclude due to data restrictions, may be the main driver for benefits from coastal and marine margins and from mountains, heathlands, and moors. A further bias from holiday activities might exist in MacKerron and Mourato (2013) as well as in the present study, as effects on life satisfaction from holiday periods that take place shortly before the time of the interview cannot be controlled for.

8. Conclusions

This paper analyzes changes in life satisfaction resulting from moving to a greener living environment. It is a genuine contribution to the literature, as earlier empirical life-satisfaction analyses on benefits from green land cover either tend to focus on urban areas only or cannot control for selection bias or vacation effects when considering green land cover in and outside

¹⁷ In deriving MWTPs for land-cover changes, distance from mountains or the coast cannot directly be included in the present analysis, as it is highly correlated with land-cover types such as forests. Therefore, dummies for living at a maximum distance of 100 km from the coast or from mountains are included to control for any recreational effects.

urban areas. More specifically, this paper estimates benefits accruing from moving to a greener living environment resulting from increases in water areas, forest areas, agricultural areas, heathlands, moors and low-vegetation areas alongside green urban areas. One major advantage of the analysis is its high degree of regional disaggregation at the municipality level for Germany, which facilitates detailed analyses of effects from a green living environment. A second advantage is that our empirical model is based on economic theory and accounts for both selection bias and income endogeneity. Finally, a large number of individual and housing characteristics including housing costs and migration costs are controlled for.

In summary, the outcome of this study is that individuals benefit from moving to a greener living environment. The benefits from moving to a living environment featuring an increase of 1 km² of water area and urban green area (forest area and agricultural area) are largest (lowest), representing 28 percent and 13 percent (1 percent for both) of household income, respectively. In line with economic theory, empirical results suggest that benefits from changes in green land cover depend entirely on scarcity of land-cover types. MWTPs are largest (lowest) for land-cover categories that are scarce (more plentiful).

In comparison to earlier studies, our empirical analysis has come up with several insights that are worthy of note. First, in contrast to earlier cross-sectional findings, the use of individual fixed effects yields MWTP estimates with expected signs, notably for green urban areas. Other reasons for differences in effects might be due to differences in the level of aggregation, regional differences in land cover types, the focus on migrants only in the present study, differences in regional boundaries, weighting of the estimation etc.. Second, focusing on the living environment only corrects for upward bias connected with vacationing in estimates for specific land cover categories such as marine and coastal margins or mountains, heathlands and moors. This emphasizes the importance of focusing on the living environment only and/or separately analyzing natural land-cover benefits specific to recreational sites (depending on research interests). Finally, focusing on changes in green land cover for internal migrants provides more significant effects, as effects for non-migrants tend to be insignificant. The main reason is that changes in land cover tend to be small for non-migrants and are likely to be captured by individual fixed effects in panel analyses.

Some further insights from robustness checks concerning the estimation of benefits from moving to a greener living environment are worthy of discussion. First, when using changes in green land cover for both migrants and non-migrants instead of changes for migrants only

in the derivation of benefits from changes in green land cover, the benefits of green land cover tend to be downscaled. More specifically, benefits from green land cover are scaled by a factor of 0.8 when considering both migrants and non-migrants rather than migrants only. Second, benefits from green land cover will be overestimated if the distance from large cities is not accounted for in the empirical analysis. More specifically, leaving distance from large cities out of account in our empirical life-satisfaction model turned out to increase benefits from green land cover by a factor of 1.25.

Appendix

Appendix A.1: Settlement-structural municipality-type aggregation

Aggregation	Settlement structural municipality types (BBSR)
<i>Large cities</i>	Major large city
	Large city in agglomeration county
	Large city in urban county
<i>Other regions</i>	Center of high-density agglomeration county
	Other municipality in high-density agglomeration county
	Center of dense agglomeration county
	Other municipality in dense agglomeration county
	Center of rural agglomeration county
	Other municipalities in rural agglomeration county
	Center of dense urban county
	Other municipality in dense urban county
	Center of rural urban county
	Other municipalities in rural urban county
	Center of rural county with higher density
	Other municipalities in rural county with higher density
	Center of rural county with lower density
	Other municipality in rural county with lower density

Source: Own compilation based on BBSR.

Appendix A.2: Summary statistics

Variable	Mean	SD
Life satisfaction		
Life satisfaction (1 = very dissatisfied and 10 = very satisfied)	7.1014	1.5934
Income and housing		
Ln real net household equivalent income (log of Euros)	9.9969	0.4802
Ln real rents per square meter (log of Euros)	3.4496	0.9549
Demographic characteristics		
Number of persons living in household	2.9402	1.2103
Number of children in household	0.6268	0.9199
Age of individual squared	2,124	873
Health status		
*No hospitalization last year (1 = yes, 0 = no)	0.9231	0.2664
Hospitalization last year (1 = yes, 0 = no)	0.0769	0.2664
Marital status		
*Single, not living with partner (1 = yes, 0 = no)	0.1372	0.3440
Single, living with partner (1 = yes, 0 = no)	0.0597	0.2369
Married, living with partner (1 = yes, 0 = no)	0.6899	0.4626
Separated, not living with partner (1 = yes, 0 = no)	0.0122	0.1098
Separated, living with partner (1 = yes, 0 = no)	0.0029	0.0536
Divorced, not living with partner (1 = yes, 0 = no)	0.0515	0.2210
Divorced, living with partner (1 = yes, 0 = no)	0.0328	0.1781
Widowed, not living with partner (1 = yes, 0 = no)	0.0110	0.1043
Widowed, living with partner (1 = yes, 0 = no)	0.0029	0.0029
Education level		
Years in education	12.8010	2.7491
Citizen status		
*German citizen (1 = yes, 0 = no)	0.9551	0.2071
Non-German citizen (1 = yes, 0 = no)	0.0449	0.2071
Interview status		
First interview (1 = yes, 0 = no)	0.0174	0.1306
Second interview (1 = yes, 0 = no)	0.0205	0.1418
Third or subsequent interview (1 = yes, 0 = no)	0.9621	0.1909
Mover status		
*No moves (1 = yes, 0 = no)	0.9762	0.1525
Move 'within' municipalities (1 = yes, 0 = no)	0.0238	0.1525
Migration characteristics		
*Not migrating 'across' municipalities (1 = yes, 0 = no)	0.9882	0.1079
Migrating 'across' municipalities (1 = yes, 0 = no)	0.0118	0.1079
Migration distance (in 100 km)	0.0071	0.1455
Total number of observations	29,901	

Appendix A.2: Summary statistics (cont.)

Variable	Mean	SD
Housing characteristics		
Ln size of house/flat (in m ²)	4.6752	0.3961
Construction year: < 1918	0.1479	0.3550
Construction year: 1918 - 1948	0.1464	0.3535
Construction year: 1949 - 1971	0.2164	0.4118
Construction year: 1972 - 1980	0.1331	0.3397
Construction year: 1981 - 1990	0.1296	0.3359
Construction year: 1991 - 2000	0.1686	0.3744
*Construction year: > 2000	0.0580	0.2338
*Not owner of house/flat	0.3737	0.4838
Owner of house/flat	0.6263	0.4838
*No central heating	0.0270	0.1621
With central heating	0.9730	0.1621
*No balcony/terrace	0.1574	0.3642
With balcony/terrace	0.8426	0.3642
*No basement	0.0443	0.2058
With basement	0.9557	0.2058
*No garden	0.2634	0.4405
With garden	0.7366	0.4405
*No kitchen in house/flat	0.0032	0.0566
Kitchen in house/flat	0.9968	0.0566
*No hot running water/boiler in house/flat	0.0017	0.0409
With hot running water/boiler in house/flat	0.9983	0.0409
*No telephone in house/flat	0.0026	0.0513
With telephone in house/flat	0.9974	0.0513
*House/flat in good shape	0.7303	0.4438
House/flat needs to be refurbished	0.2697	0.4438
*Detached or semi-detached house	0.0297	0.1697
Farm building	0.4225	0.4940
Terraced house	0.1921	0.3940
Apartment or other building	0.3474	0.4761
High-rise building	0.0084	0.0912
*Private household	0.9997	0.0183
Hall of residence/home	0.0003	0.0183
Labor characteristics		
Ln real equivalent predicted labor earnings (in €)	9.9463	0.6134
*Temporary contract	0.0834	0.2765
Permanent contract	0.9166	0.2765
Job tenure	12.6487	10.3278
Actual working hours	38.3654	12.9485
Actual working hours squared	1,639.5570	944.5830
Total number of observations	29,901	

Appendix A.2: Summary statistics (cont.)

Variable	Mean	SD
Regional land cover characteristics		
Ln settlement and traffic	2.9948	0.6951
Ln green urban	1.2191	0.7444
Ln agriculture	3.6893	0.5612
Ln forest	3.0198	0.7623
Ln heathland, moor and little vegetation	0.2624	0.4566
Ln water	0.9350	0.6628
Regional land cover characteristics - Non-migrants (NM_)		
NM_Ln settlement and traffic	2.9602	0.7633
NM_Ln green urban	1.2058	0.7515
NM_Ln agriculture	3.6451	0.6853
NM_Ln forest	2.9844	0.8247
NM_Ln heathland, moor and little vegetation	0.2597	0.4550
NM_Ln water	0.9247	0.6672
Regional economic characteristics at the municipality level		
Distance from large cities (in km)	23.2035	23.2872
Regional real purchasing power (in € per head)	17.7624	2.5571
Regional unemployment (in %)	9.4149	4.7348
Regional economic characteristics at the municipality level - Non-migrants (NM_)		
NM_Distance from large cities (in km)	22.9216	23.2935
NM_Regional real purchasing power (in € per head)	17.5473	3.1818
NM_Regional unemployment (in %)	9.3246	4.8168
Regional climate characteristics		
Standard deviation of monthly mean temperature	6.5041	0.3965
Standard deviation of monthly mean precipitation	12.3714	5.1452
Regional climate characteristics - Non-migrants (NM_)		
NM_Standard deviation of monthly mean temperature	6.4269	0.8046
NM_Standard deviation of monthly mean precipitation	12.2167	5.2783
Regional distance from recreational sites		
Not within 100 km of coast	0.8891	0.3140
Within 100 km of coast	0.1109	0.3140
Not within 100 km of mountains	0.9587	0.1991
Within 100 km of mountains	0.0413	0.1991
Regional distance from recreational sites - Non-migrants (NM_)		
NM_Not within 100 km of coast	0.8903	0.3126
NM_Within 100 km of coast	0.1097	0.3126
NM_Not within 100 km of mountains	0.9594	0.1974
NM_Within 100 km of mountains	0.0406	0.1974
Year dummies		
*Year 2006 (1 = yes, 0 = no)	0.1948	0.3961
Year 2007 (1 = yes, 0 = no)	0.2078	0.4057
Year 2008 (1 = yes, 0 = no)	0.2072	0.4053
Year 2009 (1 = yes, 0 = no)	0.1988	0.3991
Year 2010 (1 = yes, 0 = no)	0.1914	0.3934
Total number of observations	29,901	

Source: Own calculations based on GSOEP. *Reference categories. Following Luechinger (2009), variables describing marital status are a combination of standard information on marital status (such as being married) and living or not living with a partner. Abbreviations: BBSR= Bundesinstitut für Bau-, Stadt- und Raumforschung; NM_=interaction with non-migrant dummy; SD=Standard Deviation.

**Appendix A.3: Changes in environmental characteristics
and life satisfaction for German municipalities**

Life satisfaction	(1)	
	Coef.	t-stat
<i>Socio-economic characteristics</i>		
Ln real equivalent net household income (instrumented)	1.2649 **	2.51
Ln real equivalent household rents/m ²	-0.0212	-1.05
Age squared	0.0018 ***	2.72
Number of people living in hh	0.2035 ***	2.97
Number of children	0.1114 *	1.81
Not hospitalized last year	<i>Reference group</i>	
Hospitalized last year	-0.11176 **	-2.01
Single, not living with partner	<i>Reference group</i>	
Single, living with partner	-0.3380 *	-1.72
Married, living with partner	-0.3213	-1.37
Separated, not living with partner	-0.5410 *	-1.89
Separated, living with partner	-0.3373	-0.97
Divorced, not living with partner	0.1895	0.56
Divorced, living with partner	-0.6165 *	-1.70
Widowed, not living with partner	-0.3358	-0.69
Widowed, living with partner	1.2398	0.93
Years in education	-0.0662	-1.61
German citizen	<i>Reference group</i>	
Non-German citizen	0.2632	1.01
First interview	0.2049 *	1.68
Second interview	0.1332	1.25
Third or subsequent interview	<i>Reference group</i>	
No moves 'within' municipalities	<i>Reference group</i>	
Move 'within' municipalities	0.0333	0.39
<i>Housing characteristics</i>		
Ln size of house/flat in m ²	-0.0739	-0.67
Construction year: < 1918	-0.0637	-0.34
Construction year: 1918 - 1948	-0.0321	-0.20
Construction year: 1949 - 1971	-0.0306	-0.21
Construction year: 1972 - 1980	-0.1068	-0.63
Construction year: 1981 - 1990	-0.2884 *	-1.65
Construction year: 1991 - 2000	0.0572	0.41
Construction year: > 2000	<i>Reference group</i>	
Not owner of house/flat	<i>Reference group</i>	
Owner of house/flat	-0.1629 *	-1.78
No central heating	<i>Reference group</i>	
With central heating	-0.0982	-0.66
No balcony/terrace	<i>Reference group</i>	
With balcony/terrace	0.0034	0.05

**Appendix A.3: Changes in environmental characteristics
and life satisfaction for German municipalities (cont.)**

	(1)	
	Coef.	t-stat
No basement	<i>Reference group</i>	
With basement	-0.1249	-1.78
No garden	<i>Reference group</i>	
With garden	-0.0426	-0.58
No kitchen in house/flat	<i>Reference group</i>	
Kitchen in house/flat	0.0083	0.03
With hot running water/boiler in house/flat	<i>Reference group</i>	
No hot running water/boiler in house/flat	-0.2418	-0.86
No telephone in house/flat	<i>Reference group</i>	
With telephone in house/flat	0.2182	0.93
House/flat in good shape	<i>Reference group</i>	
House/flat needs to be refurbished	-0.1055 **	-2.35
Detached or semi-detached house	<i>Reference group</i>	
Farm building	-0.5619	-1.62
Terraced house	-0.0598	-0.45
Apartment or other building	-0.2154 *	-1.79
High-rise building	-0.5982 **	-2.45
Private household	<i>Reference group</i>	
Hall of residence/home	1.0457 ***	4.35
 <i><u>Labor characteristics</u></i>		
Permanent contract	<i>Reference group</i>	
Temporary contract	-0.0159	-0.21
Job tenure	-0.0138 *	-1.84
Actual working hours	0.0280 ***	2.71
Actual working hours squared	-0.0004 ***	-2.88
 <i><u>Regional land cover characteristics (in log)</u></i>		
Ln settlement and traffic	<i>Reference group</i>	
Ln green urban	0.3600 *	1.95
Ln agriculture	0.6215 *	1.96
Ln forest	0.4041 **	2.02
Ln heathland, moor and little vegetation	-0.2670	-1.35
Ln water	0.5229 **	2.43
 <i><u>Regional land cover characteristics (in log) - Non-migrants (NM_)</u></i>		
NM_ Ln settlement and traffic	<i>Reference group</i>	
NM_ Ln green urban	-0.1079	-0.59
NM_ Ln agriculture	-0.3476	-1.21
NM_ Ln forest	-0.1256	-0.13
NM_ Ln heathland, moor and little vegetation	0.2013	1.06
NM_ Ln water	-0.3324	-1.65

**Appendix A.3: Changes in environmental characteristics
and life satisfaction for German municipalities (cont.)**

	(1)	
	Coef.	t-stat
<u>Regional economic characteristics at the municipality level</u>		
Distance from large cities (in km)	0.0172 **	2.00
Regional real purchasing power (in € per head)	0.0373	0.66
Regional unemployment (in %)	-0.0020	-0.06
<u>Regional economic characteristics at the municipality level - Non-migrants (NM_)</u>		
NM_Distance from large cities (in km)	-0.0045	-0.66
NM_Regional real purchasing power (in € per head)	-0.0167	-0.35
NM_Regional unemployment (in %)	0.0076	0.22
<u>Regional climate characteristics</u>		
Standard deviation of monthly mean temperature	-0.8704	-1.58
Standard deviation of monthly mean precipitation	0.0234	0.55
<u>Regional climate characteristics - Non-migrants (NM_)</u>		
NM_Standard deviation of monthly mean temperature	0.3370	1.11
NM_Standard deviation of monthly mean precipitation	-0.0256	-1.04
<u>Regional distance from recreational sites</u>		
Not within 100 km of coast		<i>Reference group</i>
Within 100 km of coast	-0.3389	-0.60
Not within 100 km of mountains		<i>Reference group</i>
Within 100 km of mountains	0.2660	0.52
<u>Regional distance from recreational sites - Non-migrants (NM_)</u>		
NM_Not within 100 km of coast		<i>Reference group</i>
NM_Within 100 km of coast	0.3897	1.03
NM_Not within 100 km of mountains		<i>Reference group</i>
NM_Within 100 km of mountains	0.2148	0.48
<u>Effects from migration</u>		
Migrating 'across' municipalities		<i>Reference group</i>
Not migrating 'across' municipalities	0.2889	0.09
Migration distance	0.0160	0.15
<i>Individual fixed effects</i>	<i>Yes</i>	
<i>Year effects</i>	<i>Yes</i>	
<i>Instrumentation of household income</i>	<i>Yes</i>	
<i>Number of persons</i>	9,562	
<i>Average observation per person</i>	4.6	
<i>Observations</i>	29,901	

Source: Own calculations. The model is estimated by OLS. Robust standard errors are two-way clustered for person and municipality number. Ln real equivalent household income is instrumented with ln real equivalent predicted labor earnings. T-statistics are reported. * indicates significant at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level. Abbreviation: NM_=interaction with non-migrant dummy.

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Part II: Methodological Advances

Paper 4:
Uncovering Causal Effects of Income on Life Satisfaction using
Permanent Income Expectations*

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Abstract

One of the core policy implications of the life satisfaction approach is the derivation of monetary estimates for benefits deriving from changes in environmental amenities. A major issue related to the application of this method is measurement error in income, which might result in an overestimation of monetary measures. This paper presents an instrumental variable strategy by matching households based on their investment decisions, which is derived from Friedman's concept of permanent income. Our main finding is that the income effect is increased by a factor of four when instrumented with matched income. This yields a correction of the income effect that is slightly above findings from instrumenting income with predicted labor income, an instrument previously proposed in the life satisfaction literature. In contrast to predicted labor earnings, our instrument has the advantage of being applicable to a broader sample including individuals not in the labor force and older people.

Keywords: life satisfaction, instrumental variables approach, matching, Germany.

JEL codes: I31, D6

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1. Introduction

One of the most widely discussed issues in the economic literature is whether money can buy happiness. This question goes back to Easterlin (1974), showing that well-being did not rise during the post-war period in the United States despite a considerable rise in income. While micro data analyses often suggest a positive correlation between individual well-being and income, the effect is lower than expected (see e.g. Frey and Stutzer, 2002). One reason for this phenomenon is a downward bias in the income coefficient due to the endogeneity of income.

One source of downward bias due to endogeneity results from measurement error in income, which has first been discussed by Friedman (1957) within his permanent income hypothesis. The underlying idea of Friedman's permanent income hypothesis is that individuals smooth consumption and do not let it fluctuate with short run deviations in income. From this it follows that only the permanent level of income should be relevant for consumption decision making. Current income as observed by the researcher includes fluctuations around the unobserved permanent income level and is thus measured with error. Friedman shows that this measurement error in income leads to a downward bias when consumption expenditure is regressed on observed income.

Friedman's idea can be transferred to life satisfaction analyses, where life satisfaction is used as a proxy for individual welfare. Economic theory dictates that consumption decisions are relevant for welfare (see Weinzierl, 2005). However, information on consumption expenditure is rarely available in micro data. Therefore, observed income is frequently considered in life satisfaction analyses as a proxy. The measurement error that occurs by using observed income instead of the consumption-relevant permanent income level biases the income coefficient in life satisfaction analyses downwards. In addition, any coefficient estimate on additional variables included in the life satisfaction regression might be biased.

Other sources of endogeneity can lead to an upward or downward bias in the income coefficient, which is why the overall bias is unknown (see Powdthavee, 2010). Further sources of endogeneity of income include the omission of time-invariant factors such as personality traits (see Ferrer-i-Carbonell and Fritjers, 2004) or time-varying factors such as commuting activities (see Luechinger, 2009). Omitted personality traits cause an upward bias in the income coefficient, since individuals who are more satisfied with their lives also tend to earn more money. However, due to its time invariant character, this source of endogeneity can be controlled by using individual fixed effects. In contrast, omitted time varying factors are of

very different character and bias the income coefficient into different directions. Finally, a large literature analyzes further income related sources of endogeneity such as income expectations (anticipation see e.g. Di Tella et al. 2010 or De Neve and Oswald, 2012), comparisons to past income levels (adaptation, see Clark et al. 2008) and to social reference groups (social interaction, see D'Ambrosio and Frick, 2012), which cause an upward or a downward bias.

A downward bias is particularly an issue when eliciting monetary estimates for benefits deriving from changes in environmental amenities from empirical life satisfaction analyses, which are based on the marginal rate of substitution (MRS) between income and the environmental amenity in question. They are obtained by dividing the coefficient of the environmental amenity in question by the coefficient of income. If the income effect is biased downwards, this causes an overestimation of monetary measures.

Several solutions have been proposed in the literature to address biases of the income effect in life satisfaction studies, the most prominent being natural experiments and the instrumental variable approach. The rarity of natural experiments limits the application of this method, which is why only few examples using natural experiments can be found in the life satisfaction literature (see e.g. Fritjers et al., 2004 or Gardner and Oswald, 2007). The instrumental variables approach is a standard econometric approach to endogeneity. The aim of this method is to find an appropriate variable that is correlated with income, but not correlated with life satisfaction beyond its effect through the endogenous regressor (see Powdthavee, 2010). The instrumental variable approach is quite intuitive, yet, the challenge remains in finding an appropriate instrument that is not already included in the life satisfaction regression

Only three approaches can be found in the life satisfaction literature, which provide a promising instrument for income. One instrument, proposed by Powdthavee (2010), are over-time variations in the proportion of household members with pay slip information, which provides an exogenous effect on the accuracy of income statements. A second instrument is predicted labor earnings for respondents' and spouses' industry and occupation, which goes back to Luttmer (2005) (see also Luechinger, 2009¹ or Faßhauer and Rehdanz, 2015). It discards endogenous effects from income generation such as working hours, stress, health

¹ Luechinger (2009) uses spouse's working hours as a second instrument for income in the analysis. However, this instrument is less applicable, since it leads to a large loss of observations.

risks, etc., which are inherently difficult to control for (see Luechinger, 2009). Vendrik (2013) provides the most comprehensive approach when instrumenting income with predicted labor earnings by additionally combining future, present and past income effects effectively in an Error Correction Model (ECM) to address further sources of income endogeneity, namely anticipation, adaptation and social interaction. Finally, Bayer and Juessen (forthcoming) propose to use the difference between a one year lead and a two year lag of income as an instrument for income, which discards any transitory income effects.

All of these studies have in common, that the income effect is between two and three times as large when endogeneity of income is accounted for. So they all address a potential downward bias in the effect of income. However, depending on the survey being applied and the research question being analyzed, the use of these instruments is limited in further applications. First, pay slip information is not always available in general surveys. Second, predicted labor earnings is applied on a reduced sample of individuals in the labor force due to additional labor characteristics that should be controlled for (see Luechinger, 2009, Vendrik, 2013 or Faßhauer and Rehdanz, 2015) and the three year difference in income is applied for a truncated income distribution in Bayer and Juessen (forthcoming), excluding the lower and the upper 25 percent. So far, existing instruments do not enable the analysis of the whole sample.

The main objective of this paper is to contribute to the literature by presenting a new instrument for income that addresses measurement error of income to uncover causal effects of income on life satisfaction. The new instrument is obtained by matching households based on observables, including information on long-term and short-term investment decisions. The income information of matched households is used for instrumentation and applied to an ECM specification.

The main finding of our analysis is that the effect of income is four times as large when instrumenting income with matched income from households with similar investment decisions. We show that this yields a correction of the income effect that is slightly above findings from instrumenting income with predicted labor income (yielding a factor of three). Further findings indicate that our instrument is appropriate, as it passes standard exogeneity tests together with predicted labor earnings. In contrast to predicted labor earnings, our instrument has the advantage of being applicable to a broader sample including individuals not in the labor force and older people.

The remainder of the paper is structured as follows: Section 2 describes the empirical model, the instrumentation strategy and the estimation method. Section 3 presents the data. Section 4 reports the empirical results from individual fixed effects and instrumental variables regressions. Conclusions are given in Section 5.

2. Model and Methodology

2.1 The Empirical Model

To analyze the impact of changes in income on changes in life satisfaction while controlling for adaptation and social interaction² next to other socio-economic characteristics, a model similar to Vendrik's (2013) ECM is estimated as follows:

$$\Delta LS_{i,t} = \alpha^e_0 \Delta Y_{i,t} + \beta^e_0 \Delta Y_{j,t} + \gamma^e_0 \Delta X_{i,t} - \rho (LS_{i,t-1} + \alpha^* Y_{i,t-1} + \beta^* Y_{j,t-1} + \gamma^* X_{i,t-1} - f_i) + e_{i,t} \quad (1)$$

where $LS_{i,t}$ represents reported life-satisfaction on a scale from 1 to 10 of household i at time t , $Y_{i,t}$ is net equivalent household income of household i at time t and $Y_{j,t}$ is household net equivalent social reference income of household j at time t . Social reference income $Y_{j,t}$ captures any effects from changes in income of a comparison group (individuals with similar age, similar level of education and similar sex). $X_{i,t}$ are demographic and socio-economic characteristics of household i at time t and f_i are individual fixed effects. Individual fixed effects are introduced into the model to control for an important source of endogeneity, i.e. personality traits. The error term is represented by $e_{i,t}$, α 's, β 's and γ 's are parameters to be estimated. One year lags $Y_{i,t-1}$, $Y_{j,t-1}$ and $X_{i,t-1}$ of income, social reference income and other controls are considered.

We consider the change in reference income and one year lags of income and social reference income to overcome potential bias in the income effect. This means that the main focus of our analysis is on the effect of current income shocks on the change in life satisfaction represented by the coefficient α^e_0 . The use of the ECM alleviates the trade-off between including more lags to make the estimation more reliable and minimizing the loss of panel observations, which is achieved by assuming a distributed-lags specification with declining weights for higher than first order lags. Applying some transformation yields an

² Similar to Vendrik's (2013) final Error Correction specification, we do not explicitly consider anticipation effects as they are insignificant. This minimizes the loss in observations.

ECM, which includes one year lagged terms of life satisfaction, income variables and other controls. See Appendix A.1 for a derivation of the empirical life satisfaction ECM.

The ECM describes the short-run deviations and long-run adjustments to an equilibrium level of life satisfaction. The effects of current shocks of income, reference income and other controls (with the coefficients α^e_0 , β^e_0 and γ^e_0) represent the short-term deviations of life satisfaction from its long-run equilibrium. These deviations will be gradually adjusted in the next periods towards the equilibrium (error correction mechanism). The effect of lagged life satisfaction (represented by ρ) measures the speed of adjustment to equilibrium after deviation. The level of lagged income, lagged reference income and lagged other controls (coefficients α^* , β^* and γ^*) represent long-run effects that a one unit increase in these variables has on life satisfaction. These long-run effects will be distributed over the next time periods according to the rate of error correction ($-\rho$) (see Alogoskoufis and Smith, 1990).

2.2 Instrumentation Strategy

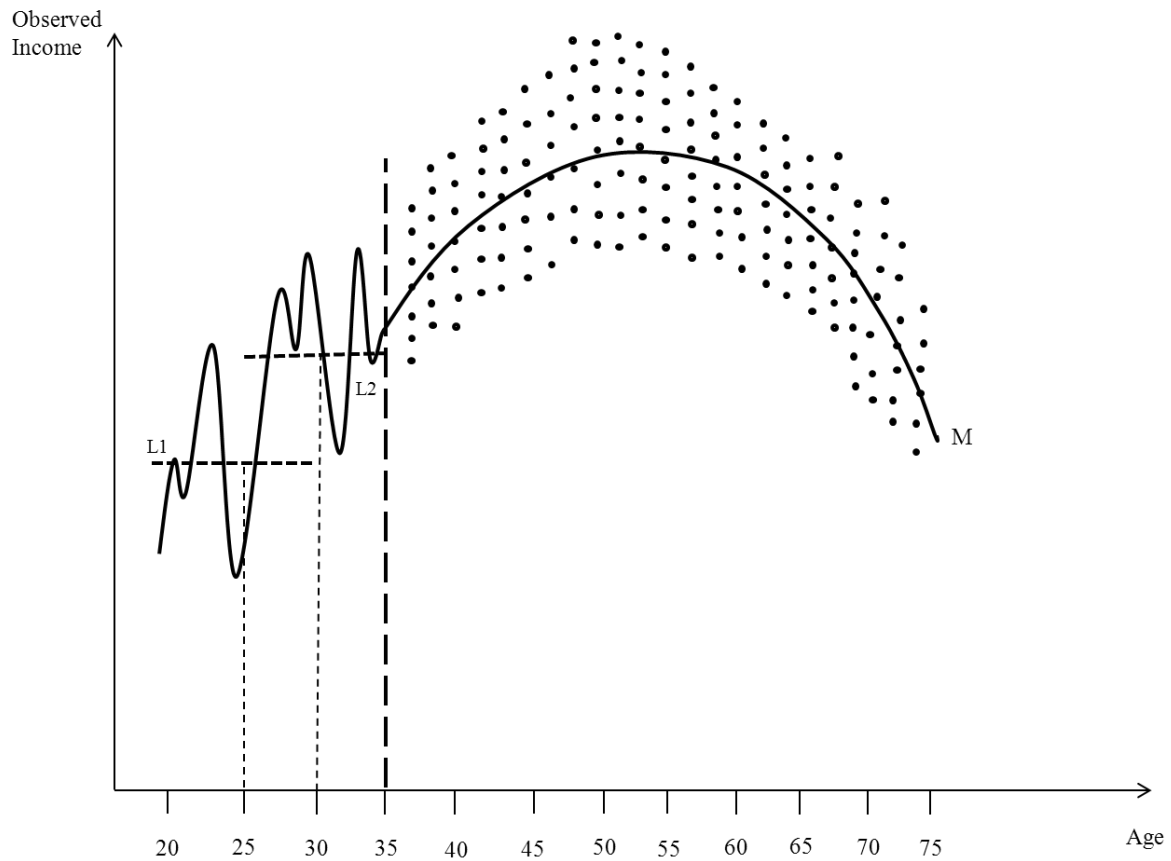
According to Friedman's permanent income hypothesis (Friedman, 1957), households smooth their consumption and do not let it fluctuate with short-run deviations in income. Current income of individual i hence can be differentiated into a permanent and a transitory component as follows:

$$Y_{i,t} = PermY_{i,t} + \varepsilon_{i,t}, \quad (2)$$

where $Y_{i,t}$ is again current income of individual i at time t as observed by the researcher, $PermY_{i,t}$ is the unobserved permanent income level of individual i at time t and $\varepsilon_{i,t}$ is transitory income of individual i at time t . According to Friedman, the permanent component reflects those factors that determine capital wealth, personality or ability, occupation or location of the economic activity, among others. The transitory component of income captures all other factors, which are accidental in nature or occur by chance. However, in contrast to Friedman, we assume that business cycle effects are part of the permanent income level as they tend to lead to large autocorrelation of income over time.

The permanent income hypothesis is based on the assumption that individuals' behavior changes when permanent income changes, but that individuals' behavior is unaffected by transitory shocks to income. From this it follows that only the permanent income level should be relevant for consumption decisions. In his work, Friedman shows that a regression of observed consumption on observed income would underestimate the effect of income on

Figure 1: Permanent Income Expectations



Source: Own compilation according to Friedman (1957).

consumption. This is known as attenuation bias. The measurement error that is existent in observed income biases the income coefficient downwards. Friedman argues that the average marginal propensity to consume derived from lifetime income, or from income over a longer time period, should provide better information on the “true” marginal propensity to consume.

This idea can be transferred to life satisfaction analyses. Economic theory dictates that the measure relevant for welfare is consumption, not income (see Weinzierl, 2005). Observed income, which includes fluctuations around the unobserved permanent income level, is a poor proxy for expenditures on consumption in life satisfaction analyses. Only its permanent level should affect life satisfaction, while the transitory component should have no effect. If the observed income level is introduced into the life satisfaction regression, the effect of income on life satisfaction is biased downwards similar to the effect of observed income on consumption.

Figure 1 provides some foundations on the discussion of permanent income. Consider an individual, who is assumed to be 35 years of age. Information on past income between the age of 20 and 35 is given, while future income is uncertain. The scatter of dots shall represent

possible income distributions as expected by the individual at age 35 for each future date.³ It has to be emphasized that these income distributions reflect expectations of future income realizations and not the distribution of realized income of other individuals at the same age is often suggested for simplification (see Vendrik, 2013). According to Friedman, expectations of future income might include among other information realized income of individuals of a different age, but with similarities in other factors that determine permanent income such as occupation or wealth.

Several approximations of the permanent income level are imaginable. Following Friedman's argumentation, an average of income over some years can be applied. Examples, where an average is built from 5 years before and 5 years after the date in question is line L1 for the age of 25 and line L2 for the age of 30. Knabe and Rätzel (2007) follow this approach taking a ten year average for analyzing the effect of permanent income on job satisfaction. One shortcoming of this approach is that it crucially depends on the assumption that consumption (and permanent income) is proportional to average income over the time period in question.

One further approximation of the permanent income level might be the mean of the anticipated probability distribution at each age as indicated by the solid line in Figure 1. This might reflect rather short-term permanent income expectations of individuals. The major problem related to this concept of short-term permanent income expectations is that the probability distribution of expected income is unknown to the researcher.

To approximate the permanent income level using a new instrument, Friedman's idea on short-term permanent income expectations will be further developed by making two assumptions.

Assumption 1: Behavior is driven by expectations and not necessarily by realizations.

According to this assumption, we amplify Friedman's permanent income hypothesis by assuming that the permanent income level that affects consumption is the expected permanent income level and not its realization. We rewrite equation (2) as follows:

$$Y_{i,t} = E[PermY_{i,t}] + \varepsilon_{i,t}. \quad (3)$$

³ Due to a two-dimensional representation, independency of the probability distributions is assumed. In reality, dependency of probability distributions might exist. However, this issue is not serious for the discussion as follows.

Assumption 2: Similar to consumption decisions, individuals also base their investment decisions on their permanent income expectations.⁴

Ceteris paribus, the conversion of assumption 2 dictates that individuals with similar investment decisions should also have similar permanent income expectations. Considering another individual j having made the same investment decisions in period $t+1$ as individual i in period t . Observed income of individual j at time $t+1$ is given as follows:

$$Y_{j,t+1} = E[PermY_{j,t+1}] + \varepsilon_{j,t+1}. \quad (4)$$

Under the assumption that transitory income of individuals with similar investment decisions is uncorrelated, the part of income that is correlated relates to their permanent income expectations. In other words, the instrumental variable approach can be applied under the assumption that transitory shocks to income of individual j at time $t+1$ are uncorrelated with transitory shocks to income of individual i at time t :

$$\text{Corr} [\varepsilon_{i,t}, \varepsilon_{j,t+1}] = 0. \quad (5)$$

Since individuals residing in the same region and individuals observed in the same year might be affected by the same regional or national policy shock, this assumption only holds for individuals observed in different years and individuals living in different regions. As we consider individuals in proceeding years, medium and long-term shocks of national policies cannot be ruled out, which makes them part of the permanent income component.

2.3 The Estimation and Matching Method

Two estimation procedures can be applied for estimating the specified model. Ordered logit can be used, when a non-linear relationship or ordinality of the dependent variable respectively shall be taken into consideration. However, this requires an averaging of marginal effects, which is open to criticism (see e.g. Peng et al. 2002). Alternatively, Ordinary Least Squares (OLS) can be applied when error terms are adjusted for heteroscedasticity, which might be less accurate due to the linearity assumption. Ferreira-i-Carbonell and Frijters

⁴ It is important to emphasize the difference between savings and investments. In economics savings are defined as income minus consumption. Investments are defined as a purchase of financial products of value or other physical goods such as a house or a flat with an expectation of favorable future returns. Therefore, investments are only a part of savings. We think that they are better suited for revealing permanent income expectations, as investment decisions tend to be long-term-decisions in comparison to savings, which might also be rather short-term-decisions.

(2004) have shown that assuming ordinality or cardinality of the dependent variable makes little difference in a life satisfaction framework. We thus use OLS for estimating the model to allow for an easier interpretation.

Several issues arise when estimating the above specified model. First, unobserved heterogeneity might lead to bias. To remove unobserved time-invariant heterogeneity, individual fixed effects regression is applied. Second, to relax the assumption that observations are independent over time and to adjust standard errors for inter-personal correlation accordingly, clustering is applied at the individual level (see Moulton, 1990). Third, the General Method of Moments (GMM) is applied for instrumentation. This method is more efficient than the Two-Stage Least Square (2SLS) estimator in its robust version, when heteroscedasticity is an issue.

When applying the ECM, a Nickell bias might arise from including the lag of life satisfaction in the empirical model. In a panel model with individual fixed effects, the lag of the dependent variable might be correlated with the error-term. To overcome a possible bias, we follow Vendrik (2013) and apply a bias-corrected least squares dummy variable (BCLSDV) approach (see Bruno, 2005). When using the BCLSDV, the coefficient of lagged life satisfaction increases with T. Vendrik (2013) suggests that this might be due to a small T bias, which might be due to including only a one year lag of life satisfaction⁵ (see Lee, 2008) or measurement error of life satisfaction from discreteness of its scale, which might smooth out for higher T. To overcome a possible small T bias, we fix the coefficient for the lagged dependent variable by the value of an estimate obtained from a model estimated for the maximum balanced panel length of T=24. This yields an estimate of 0.25 for the coefficient $1 - \rho$ (with the Hsiao–Anderson instrumented-variable estimate 0.20 as initial value). The estimate of coefficient ρ of lagged life satisfaction in the ECM is then given by $1 - 0.25 = 0.75$. This implies that an n increase in the level of lagged life satisfaction by one unit yields a decrease in the level of current life satisfaction by 0.75. Estimates of the other parameters of equation (1) are obtained from restricting the coefficient of ρ to be equal to 0.75 and estimating it in linear form. Estimates of the long-run effects α^* , β^* and γ^* then result from dividing the estimates of the linear form by the estimate of ρ .

⁵ Higher order autoregressive models AR(p) with $p > 1$ might be assumed, which consider higher order lags of life satisfaction. However, this makes the estimation too complex and has not been tested so far.

For the derivation of the instrument, matching on observables based on the Mahalanobis distance is applied (see Rubin, 1980). This method is advantageous compared to other matching methods, when the number of observables is small, as in our case (see Section 3). The matching algorithm can be described in 4 steps. In a first step, treatment and control groups are defined. The treatment group consists of individuals living in region i at time t , while the control groups include individuals living in other regions than i at time $t+1$. This assumption is made, since individuals might be affected by the same policy shocks and independency might not be met. In a second step, the Mahalanobis distance is calculated based on observables \mathbf{X} :

$$d_{i,j} = \sqrt{(\mathbf{X}_i - \mathbf{X}_j)' \mathbf{S}^{-1} (\mathbf{X}_i - \mathbf{X}_j)}, \quad (6)$$

where the vector \mathbf{X} captures observable characteristics of investment decisions as described in section 3 and \mathbf{S} is the estimated variance-covariance matrix. In a third step, one control unit is matched to each treated unit, where mahalanobis distance is smallest. Matching with replacement is applied. Finally, steps 1-3 are repeated for all the remaining regions $j \neq i$.

3. The Data

This study is based on data from the German Socio-Economic Panel (GSOEP) for the years 1984-2010. It is a wide-ranging representative longitudinal study providing socio-economic information for approximately 20,000 individuals and 10,000 households (see Wagner et al. 2007).

We restrict the sample to West Germany, because of the longer time series and structural differences between East and West Germany. Furthermore, we consider individuals between 27 and 70 years of age. Information on investment decisions of house or apartment owners is of particular interest to us in our matching strategy (see below). House or apartment owners tend to be older, which is why we explicitly consider older people in our sample. In addition, non-German citizens are excluded, since their reference group might be hosted in their home country. Finally, self-employed individuals are excluded as they are more reluctant to state their income level (see Luechinger, 2009). The final sample then includes 99,283 individuals who stay on average 7.9 years in the sample.

In this survey, information on life satisfaction is obtained by asking individuals the following question: “*How satisfied are you with your life at present, all things considered?*”.

To answer this question individuals can choose on an ordinal scale of 1 to 10, where 1 means very dissatisfied and 10 means very satisfied.

Further information on demographic and socio-economic characteristics from the GSOEP relevant for our analysis includes net household income (after tax), rents (including imputed rents), household income from asset flows, number of adults living in the household, number of children living in the household, health status, marital status and employment status. Throughout the analysis, we deflate household income, rents and household income from asset flows to account for the fact that nominal increases in monetary measures do not affect life satisfaction, but real increases do. In addition, we apply OECD equivalence scales for household income and rents to account for the fact that the needs of a household grow with each additional household member, but – due to economies of scale in consumption - not in a proportional way. Using equivalence scales, each household type in the population is applied a value in proportion to its needs. Following the modified OECD scale, we assign 1 to the first person in the household and 0.5 to every other person aged 14 and older and 0.3 to all children under the age of 14. Net household income is then divided by the sum of these values, resulting in needs adjusted household income per person (see Atkinson and Bourguignon, 2000 and D’Ambrosio and Frick 2006 as an example). See Appendix A.1 for summary statistics of the most important variables and Appendix A.2 for a list of controls.

The choice of information for matching households with similar investment decisions is crucial for the outcome of the analysis. There is a trade-off between using more information and being more precise. For the analysis presented in this paper, *three sources* of information have been selected. First, direct information related to investment decisions is used in terms of household income from asset flows. This comprises income from interest, dividends and rents.

Second, indirect information on the investment choice (1) to have a house built and (2) on the amount of paid rents is obtained from a combination of imputed rents and actual paid rents.⁶ Imputed rents are an estimated fictitious value corresponding to the amount the household would have had to pay for property rental in absence of the possibility to live in their own property. It can be interpreted as a return on private investment in real estate rather than in the financial market (see Frick and Grabka 2003). According to its construction,

⁶Direct information on investment activities related to the choice of having a house built are stated in the GSOEP only in 2002 and 2007.

imputed rents provided in the GSOEP also include advantages of living in subsidized rented accommodation or living rent-free due to being former owner-occupiers (often outright owners), who hand over the deeds to their property to their children and keep the right to stay in their dwelling. Both, subsidized rented accommodation or living rent free, reflect an increase in consumption expenditure, which leads to a higher permanent income level of households being subsidized or living rent free, compared to those who are/do not, which is why it is in line with our instrumentation strategy. Finally, the amount of rent of households living in a flat is used to fill the gap on investment decisions for households with little investment income, no house ownership and no subsidized or rent-free housing. Decisions on renting a flat reflect rather short-term permanent income expectations.

Third, the number of adults and the number of children living in a household are used. They enter the matching procedure as separate variables. The reason for considering the number of adults and the number of children living in a household, is that investment decisions might differ depending on the family status.

In addition, we also use predicted labor earnings as a second instrument. Predicted labor earnings are obtained by regressing the natural logarithm of labor earnings provided by GSOEP for each individual on industry and occupation dummies for each year, and separately for West and East Germany. The exponential of the predicted value is summed up over household members, deflated and adjusted by the OECD equivalence scale (similar to household income and rents), which yields a final measure on real predicted equivalent labor earnings. When applying predicted labor earnings as an instrument for household income, we restrict the sample to the age brackets of 27 and 59 years of age.

4. Empirical Results

4.1 Estimation Results

Estimation results from the baseline model with individual fixed effects, and from extensions of the baseline model with GMM instrumental variable regression and clustering at presented in column (1). The effect of a current income shock on changes in life satisfaction is positive and, with a value of 0.1758, relatively small. The effect of the past level of income on the change in life satisfaction is slightly larger with a value of 0.1780. Both, the effect of the current income shock and the effect of the past level of income, are significant at the 5 percent level. Reference income effects are insignificant.

Table 2: Estimation Results

	(1)		(2)		(3)		(4)		(5)		(6)	
	Baseline model		Instrumentation with matched income		Baseline model		Instrumentation with predicted labor income		Baseline model		Instrumentation with matched income & predicted labor income	
Change in life satisfaction	coef.	t-statistic	coef.	t-statistic	coef.	t-statistic	coef.	t-statistic	coef.	t-statistic	coef.	t-statistic
Past life satisfaction	0.7500		0.7500		0.7500		0.7500		0.7500		0.7500	
Current ln hheq. income shock	0.1758 ***	7.86	0.7400 **	2.33	0.2208 ***	6.38	0.7527 ***	2.73	0.2020 ***	5.74	0.8429 ***	3.34
Past ln hheq. income level (-1)	0.1780 ***	7.38	0.8648 ***	2.92	0.2902 ***	7.53	0.3683 **	2.56	0.2540 ***	6.43	0.3915 ***	2.80
Current ln hheq. ref. income shock	0.0253	0.23	-0.0610	-0.53	0.1746	1.16	0.1604	1.06	0.0467	0.32	0.0218	0.15
Past ln hheq. ref income level (-1)	0.0192	0.22	-0.1034	-0.99	-0.0982	-0.75	-0.1028	-0.77	-0.1634	-1.32	-0.1573	-1.25
Current effect of ln hheq. income	0.1758 ***	7.86	0.7400 **	2.33	0.2208 ***	6.38	0.7527 ***	2.73	0.2020 ***	5.74	0.8429 ***	3.34
Adaptation to ln hheq. income	0.0022	0.12	0.1248	0.40	0.0694 **	2.15	-0.3844	-1.27	0.0521	1.59	-0.4514 *	-1.71
Long-run effect of ln hheq. income	0.1780 ***	7.38	0.8648 ***	2.92	0.2902 ***	7.53	0.3683 **	2.56	0.2540 ***	6.43	0.3915 ***	2.8
Current effect of ln hheq. reference income	0.0253	0.23	-0.0610	-0.53	0.1746	1.16	0.1604	1.06	0.0467	0.32	0.0218	0.15
Reinforcement of ln hheq. reference income	-0.0061	-0.06	-0.0423	-0.39	-0.2727 *	-1.82	-0.2632 *	-1.73	-0.2101	-1.45	-0.1790	-1.21
Long-run effect of ln hheq. reference income	0.0192	0.22	-0.1034	-0.99	-0.0982	-0.75	-0.1028	-0.77	-0.1634	-1.32	-0.1573	-1.25
Short-run absolute effect of ln hheq. income	0.2012 *	1.82	0.6790 **	2.16	0.3954 **	2.56	0.9130 ***	2.98	0.2487 *	1.66	0.8647 ***	3.06
Adaptation to absolute ln hheq. income	-0.0039	-0.04	0.0824	0.27	-0.2033	-1.34	-0.6475 **	-2.03	-0.1580	-1.07	-0.6304 **	-2.27
Long-run absolute effect of ln hheq. income	0.1973 **	2.23	0.7614 ***	2.96	0.1921	1.44	0.2655	1.53	0.0906	0.71	0.2342	1.37
Number of observations	99,283		99,283		57,757		57,757		53,589		53,589	
Number of individuals	12,507		12,507		8,400		8,400		8,045		8,045	

Source: Own calculations. Equations are estimated by OLS in column (1), (3), and (5) and GMM in column (2), (4), and (6) all with individual fixed effects. They include one-year-lagged year dummies, one-year-lagged state-specific time trends, current first differences and past levels of state dummies and the control variables. Hheq.=household equivalent. Robust t-tstatistics are clustered for person number. * indicates significant at the 10-percent level, ** at the 5-percent level and *** at the 1-percent level.

the individual level are presented in Table 1.⁷ Estimation results from our *baseline model* are presented in column (1). The effect of a current income shock on changes in life satisfaction is positive and, with a value of 0.1758, relatively small. The effect of the past level of income on the change in life satisfaction is slightly larger with a value of 0.1780. Both, the effect of the current income shock and the effect of the past level of income, are significant at the 5 percent level. Reference income effects are insignificant.

In a first extension of the baseline model, we *instrument income with matched income*. Empirical results suggest that income effects in the model with income instrumentation using matched income (column 2) are increased in comparison to the baseline model (column 1). The estimated income coefficient is four times as large in comparison to the baseline model (it increases from 0.1758 to 0.7400). Similarly, the effect of the past level of income increases (from 0.1780 to 0.8648). Both, the effect of the current income shock and the effect of the past level of income, are still significant at the 5 percent level. Reference income effects are again insignificant. The instrument passes the underidentification LM test at the 1 percent level of significance and has a Kleibergen-Paap rk Wald F statistic of 41.045 (as compared to the conventional required value of 10). See Appendix A.4 for estimation results of the model presented in column (2) including all controls.

In a second extension of the baseline model, we *instrument income with predicted labor earnings*. To control for omitted variable bias, we additionally control for labor characteristics similar to Luechinger (2009) (including type of contract, job tenure, actual working hours and its squared term, and job position). This and the restriction of the sample to individuals with a maximum of 59 years of age reduce our sample size. To account for this reduction, we compare the results of the extension to the baseline model specification with adjusted sample size. When instrumenting income with predicted labor income (column 4), the effect of the income coefficient increases in comparison to the baseline model (column 3). The estimated income coefficient is three times as large (it increases from 0.2208 to 0.7527). This is similar to findings in the literature, but below the increase of the effect of a current income shock when instrumenting income with matched income. The increase in the past level of income is

⁷ In column (1) and (2) the number of observations of 99,283 in comparison to the number of total observations in GSOEP is mainly restricted by the availability of the instrument „matched income“. In column (3) und (4) the number of observations of 57,757 in comparison to the number of total observations in GSOEP is mainly restricted by the availability of the instrument „predicted labor earnings“. In column (5) und (6) the number of observations of 53,589 in comparison to the number of total observations in GSOEP is mainly restricted by the availability of the instrument „matched income“ and „predicted labor earnings“ jointly.

much lower (it increases from 0.2902 to 0.3683). Both, the effect of the current income shock and the effect of the past level of income, are again significant at the 5 percent level. Reference income effects are again insignificant. The instrument passes the underidentification LM test at the 1 percent level of significance and has a Kleibergen-Paap rk Wald F statistic of 116.279 (as compared to the conventional required value of 10).

In a third extension of the baseline model, we *instrument income with both predicted labor earnings and matched income*. Instrumentation of income with predicted labor earnings and matched income (column 6) increases the income coefficient by a factor of four in comparison to the baseline model (column 5) (it increases from 0.2020 to 0.8429), which is similar to the factor obtained when instrumenting income with matched income. The income coefficient is again significant at the 5 percent level. The increase in the past level of income is lower (it increases from 0.2540 to 0.3915). It is again significant at the 5 percent level of significance. Reference income effects are insignificant. The instruments pass the underidentification LM test at the 1 percent level of significance and have a Kleibergen-Paap rk Wald F statistic of 64.278 (as compared to the conventional required value of 10). In addition, the Hansen J statistic with 3.188 and a p-value of 0.2031 does not allow rejection of the joint null hypothesis of the instruments being uncorrelated with the error term and being correctly excluded from the estimated equation, which gives us confidence that matched income, our new instrument, is appropriate.

4.2 Adaptation and Reinforcement

From the estimation results of the ECM, we can derive further information on adaptation of income and reinforcement of reference income effects from the estimation results, which provides us with further information on potential bias in the income effect next to the potential bias from measurement error. Adaptation occurs if the effect of a lagged variable is opposite to the effect of the current year variable, meaning that the effect of a variable decreases over time. Reinforcement occurs if the effect of a lagged variable is similar to the effect of the current year variable, meaning that the effect of a variable increases over time. It is presented below the estimation results in Table 1. For household equivalent income, we find some (weak) evidence of reinforcement effects in the baseline model in column (3) (at the 5 percent level of significance) and in the baseline model in column (5) (the effect is just not significant at the 10 percent level). However, instrumentation of income with predicted labor earnings in column (4) and with both, predicted labor income and matched income in

column (6) reverses the sign of the effects, implying adaptation to household equivalent income (the effect is significant at the 10 percent level in model (6), it is insignificant in model (4)).

Furthermore, we find some weak evidence of reinforcement of household equivalent reference income in the baseline model in column (3) and in the model specification with instrumentation using predicted labor earnings in column (4), the effects being significant at the 10 percent level. Similar effects are found in the baseline model (5) and in the model with instrumentation using matched income and predicted labor earnings, but they are insignificant.

Finally, short and long-run absolute income effects are presented in the last three rows of Table 1. These are the short and long-run effects of changes in the level of income at constant relative income, meaning that income and reference income change at the same percentage. They are given by the sum of the corresponding income and reference income effects. We find significant short-run absolute effects of income and adaptation effects to absolute income. Long-run absolute effects of income are insignificant. From this follows, that if individuals received a rise in their income similar to their reference group, their life satisfaction increases initially, but returns to their old life satisfaction level as they get used to the rise in their income and/or because they become aware that they cannot consume more than their reference group. These findings of adaptation and reinforcement are similar to findings by Vendrik (2013).

In contrast to Vendrik (2013), we do not find any adaptation effects to absolute income in the baseline model in column (1) and in the model specification when instrumenting income with matched income in column (2). Instead, we find significant short-run absolute effects of income and significant long-run absolute effects of income. This is a result of the larger sample size (results for instrumenting income using matched income with adjusted sample size are not presented). The larger sample also includes older people. One explanation might be that richer people tend to belong to the older group of people, which has a reference group with higher average income. However, the overall income distribution is much wider than the reference income distribution in our sample, which is why older people have higher relative incomes (see Vendrik, 2013). This higher relative income explains the positive long-run effect of income.

5. Conclusions

This paper contributes to one of the core policy implications of the life satisfaction approach – the provisioning of monetary estimates for benefits deriving from changes in environmental amenities. In life satisfaction studies, observed income is used instead of the consumption-relevant permanent income level. This measurement error biases the income coefficient downwards, which leads to an upward bias of monetary estimates. Only little research has been dedicated to finding appropriate instruments for income in life satisfaction studies, which is why its applications are limited. This paper proposes a new instrument towards a more accurate estimation of the income effect, which is based on Friedman's concept of permanent income.

The main finding of our analysis is that the income effect is increased by a factor of four when measurement error of income is accounted for by using matched income from households with similar investment decisions as an instrument. This is slightly above findings when instead using predicted labor income as an instrument for income, accordingly to which the income effect is three times as large. We are confident that our instrument is appropriate, as it passes standard exogeneity tests together with predicted labor earnings. In contrast to predicted labor earnings, our instrument has the advantage of being applicable to a broader sample, including individuals not in labor force and older people.

The implications of our findings are, that monetary estimates for benefits deriving from changes in environmental amenities are scaled by a factor of 0.25 when endogeneity of income is accounted for.

Several limitations and issues are worth discussing. First, further variables should be considered in the matching procedure to improve the strength of the instrument. Pensions might provide another important source of information, which have not been considered due to data restrictions. Second, a simple matching algorithm based on the Mahalanobis distance is applied in this study. It is suitable for matching on observables, where the number of observables is small. One shortcoming of this method is that the same weights are applied to all observables. Further matching methods might be tested in future analyses, which put different weights on different variables.

Appendix

Appendix A.1:

The basic empirical life satisfaction equation specifies life satisfaction in terms of future, current and lagged values of income, social reference income, and other explanatory variables as suggested by Vendrik (2013):

$$\begin{aligned}
 LS_{i,t} = & \alpha_{+1} \ln Y_{i,t+1} + \alpha_0 \ln Y_{i,t} + \sum_{s=0}^{\infty} \alpha_{-1} (1-\rho)^s \ln Y_{i,t-s} \\
 & + \beta_{+1} \ln Y_{j,t+1} + \beta_0 \ln Y_{j,t} + \sum_{k=0}^{\infty} \beta_{-1} (1-\rho)^k \ln Y_{j,t-k} \\
 & + \gamma_{+1} \ln X_{i,t+1} + \gamma_0 \ln X_{i,t} + \sum_{l=0}^{\infty} \gamma_{-1} (1-\rho)^l X_{i,t-l} \\
 & + f_i + e_{i,t}.
 \end{aligned} \tag{A.1}$$

In this empirical life satisfaction model, adaptation effects are considered by distributed lags of income, social reference income and the other variables with weights that decline exponentially with a uniform factor given by $1 - \rho$ (with $0 < \rho \leq 1$). The future and current-year coefficients (with subscripts $+1$ and 0) in equation (A.1) represent short-run effects of the variables. When the signs of the coefficients of the one year lagged variables (with subscripts -1) are opposite (similar) to those of the current-year coefficients, they represent the effects of hedonic adaptation (reinforcement).

The long-run effects of changes in variables are the net results of short-run and hedonic adaptation (or reinforcement) effects on life satisfaction (=the sum of future, current and past-year coefficients of the variables). Using the information that $\alpha_{-1} \sum_{s=0}^{\infty} (1-\rho)^s = \alpha_{-1}/\rho$, the long-run effects can be rewritten as:

$$\alpha^* = \alpha_{+1} + \alpha_0 + \alpha_{-1}/\rho \qquad \beta^* = \beta_{+1} + \beta_0 + \beta_{-1}/\rho \qquad \gamma^* = \gamma_{+1} + \gamma_0 + \gamma_{-1}/\rho. \tag{A.2}$$

In the next step, the model will be simplified according to Vendrik (2013) as it is not estimable due to the large number of lags. The distributed lags in equation (A.1) can be expressed in terms of the lag operator L as $\alpha_{-1} \sum_{s=0}^{\infty} \alpha_{-1} \left[(1-\rho)L \right]^s \ln Y_{i,t-s} = \alpha_{-1} \ln Y_{i,t-1} / \left[(1-\rho)L \right]$, and analogously for the parameters β_{-1} and γ_{-1} . When applying the Koyck transformation $(1-\rho)L$ to each side of equation (A.1) and rearranging the equation the following autoregressive equation of order 1 (AR(1)) with one year lag of life satisfaction is obtained:

$$LS_{i,t} = \alpha_{+1} \ln Y_{i,t+1} + \alpha_0^a \ln Y_{i,t} + \alpha_{-1}^a \ln Y_{i,t-1}$$

$$\begin{aligned}
& + \beta_{+1} \ln Y_{j,t+1} + \beta_0^a \ln Y_{j,t} + \beta_{-1}^a \ln Y_{j,t-1} \\
& + \gamma_{+1} X_{i,t+1} + \gamma_0^a X_{i,t} + \gamma_{-1}^a X_{i,t-1} \\
& + (1-\rho) LS_{i,t-1} + f_i^a + e_{i,t}^a.
\end{aligned} \tag{A.3}$$

where

$$\begin{aligned}
\alpha_0^a &= \alpha_0 - (1-\rho)\alpha_{+1}, & \alpha_{-1}^a &= \alpha_{-1} - (1-\rho)\alpha_0, \\
\beta_0^a &= \beta_0 - (1-\rho)\beta_{+1}, & \beta_{-1}^a &= \beta_{-1} - (1-\rho)\beta_0, \\
\gamma_0^a &= \gamma_0 - (1-\rho)\gamma_{+1}, & \gamma_{-1}^a &= \gamma_{-1} - (1-\rho)\gamma_0, \\
f_i^a &= \rho f_i, & e_{it}^a &= e_{it} - (1-\rho)e_{i,t-1},
\end{aligned} \tag{A.3a}$$

Rewriting the autoregressive equation in terms of first differences and lagged levels of the variables results in the following ECM specification in linear form (see Algoskoufis and Smith, 1990):

$$\begin{aligned}
\Delta LS_{i,t} &= \alpha_{+1} \Delta \ln Y_{i,t+1} + \alpha_0^e \Delta \ln Y_{i,t} + \beta_{+1} \Delta \ln Y_{j,t+1} + \beta_0^e \Delta \ln Y_{j,t} \\
& + \gamma_{+1} \Delta X_{i,t+1} + \gamma_0^e \Delta X_{i,t} \\
& - \rho LS_{i,t-1} + \tilde{\alpha}^* \ln Y_{i,t-1} + \tilde{\beta}^* \ln Y_{j,t-1} + \tilde{\gamma}^* X_{i,t-1} \\
& + f_i^a + e_{i,t}^a.
\end{aligned} \tag{A.4}$$

where

$$\tilde{\alpha}^* = \rho \alpha^*, \quad \tilde{\beta}^* = \rho \beta^*, \quad \tilde{\gamma}^* = \rho \gamma^* \tag{A.4a}$$

Changes in the leads of variables ($\Delta \ln Y_{i,t+1}$, $\Delta Y_{j,t+1}$ and $\Delta X_{i,t+1}$) are excluded in the present analysis, as their effects are insignificant.

Appendix A.2: Summary statistics of the most important variables

Variable	Mean	Standard Deviation
Life Satisfaction (1 = very dissatisfied and 10 = very satisfied)	7.19	1.71
-Between		1.34
-Within		1.15
Household real equivalent income (2006 Euros)	23,330	22,965
-Between		24,841
-Within		11,963
Ln household real equivalent income (2006 Euros)	9.91	0.51
-Between		0.49
-Within		0.24
Household real equivalent reference income (2006 Euros)	23,251	6,947
-Between		6,947
-Within		2,519
Ln household real equivalent reference income (2006 Euros)	10.01	0.28
-Between		0.28
-Within		0.10
Household real equivalent matched income (2006 Euros)	22,355	18,433
-Between		14,974
-Within		13,670
Ln household real equivalent matched income (2006 Euros)	9.86	0.54
-Between		0.37
-Within		0.42
Household real equivalent predicted labor earnings (2006 Euros)	23,138	13,170
-Between		11,770
-Within		7,371
Ln household real equivalent predicted labor earnings (2006 Euro)	9.89	0.59
-Between		0.53
-Within		0.35

Appendix A.3: List of control variables

Variables	Scale
Ln real rents (including imputed rents)	0-11.64
Ln real hheq. asset flow	0-15.66
Age of individual squared	784-4900
Number of adult in hh	1-10
Number of children in hh	0-10
Not being hospitalized last year (reference group)	0-1
Being hospitalized last year	0-1
Education years	7-18
Single, no partner (reference group)	0-1
Single, partner	0-1
Separated, no partner	0-1
Separated, partner	0-1
Divorced, no partner	0-1
Divorced, partner	0-1
Widowed, no partner	0-1
Widowed, partner	0-1
One person hh	0-1
Married couple without children hh (reference group)	0-1
Single parent hh	0-1
Couple with children below 16 hh	0-1
Couple with children above 16 hh	0-1
Couple with children below and above 16 hh	0-1
Multiple generation hh	0-1
Other type of hh	0-1
Working	0-1
Secondary job	0-1
Not in education	0-1
Maternity leave	0-1
Unemployed	0-1
Non-working	0-1
Residing in West-Berlin	0-1
Residing in Schleswig-Holstein	0-1
Residing in Hamburg	0-1
Residing in Lower Saxony	0-1
Residing in Bremen	0-1
Residing in Hessen	0-1
Residing in Rheinland	0-1
Residing in Baden-Württemberg	0-1
Residing in Bavaria	0-1
Residing in Nordrhein-Westfalen (reference group)	0-1
State specific time trends	0-25
Year dummies	1985-2010

**Appendix A.4: Full empirical results from a model
with instrumentation using matched income**

Change in life satisfaction	(2)	
	Instrumentation with matched income	
	coef.	t-statistic
Life satisfaction (-1)	0.7500	
Δ Ln real hheq. income	0.7400 **	2.33
Ln real hheq. income (-1)	0.8648 ***	2.92
Δ Real ln hheq. ref. income	-0.0610	-0.53
Ln real hheq. ref income (-1)	-0.1034	-0.99
Δ Ln real rents (including imputed rents)	0.0086 ***	3.36
Ln real rents (including imputed rents) (-1)	0.0083 **	2.59
Δ Ln real hheq. asset flow	0.0031	0.40
Ln real hheq. asset flow (-1)	-0.0029	-0.29
Δ Age of individual squared	0.0003	0.59
Age of individual squared (-1)	0.0005 ***	4.31
Δ Number of adults in hh	0.1189 ***	4.33
Number of adultst in hh (-1)	0.0088	0.38
Δ Number of children in hh	0.1365 ***	3.81
Number of children in hh (-1)	0.0487	1.41
Δ Not being hospitalized last year	<i>Reference group</i>	
Not being hospitalized last year (-1)	<i>Reference group</i>	
Δ Being hospitalized last year	-0.1787 ***	-10.58
Being hospitalized last year (-1)	-0.2193 ***	-9.28
Δ Education years	0.0043	0.20
Education years (-1)	0.0025	0.16
Δ Single, no partner	<i>Reference group</i>	
Single, no partner (-1)	<i>Reference group</i>	
Δ Single, partner	-0.1915 ***	-2.70
Single, partner (-1)	-0.1133 *	-1.71
Δ Seperated, no partner	-0.3178 **	-2.59
Separated, no partner (-1)	-0.0768	-0.71
Δ Separated, partner	-0.3889 ***	-2.93
Separated, partner (-1)	-0.1804	-1.31
Δ Divorced, no partner	-0.1569	-1.22
Divorced, no partner (-1)	0.0733	0.76
Δ Divorced, partner	-0.2133 **	-2.17
Divorced, partner (-1)	0.0759	0.93
Δ Widowed, no partner	-0.8623 ***	-4.13
Widowed, no partner (-1)	0.0890	0.63
Δ Widowed, partner	-0.3009	-1.12
Widowed, partner (-1)	0.6392 ***	3.16

Appendix A.4 (continued):

	(2)	
	Instrumentation with matched income	
Change in life satisfaction	coef.	t-statistic
Δ One person hh	-0.2573 **	-2.49
One person hh (-1)	-0.0330	-0.37
Δ Married couple without children hh	<i>Reference group</i>	
Married couple without children hh (-1)	<i>Reference group</i>	
Δ Single parent hh	-0.2052	-1.42
Single parent hh (-1)	0.0343	0.27
Δ Couple with children below 16 hh	-0.0346	-0.68
Couple with children below 16 hh (-1)	0.0272	0.58
Δ Couple with children above 16 hh	-0.0520	-1.23
Couple with children above 16 hh (-1)	-0.0140	-0.37
Δ Couple with children below and above 16 hh	-0.0432	-0.82
Couple with children below and above 16 hh (-1)	0.0787	1.45
Δ Multiple generation hh	-0.2416 **	-2.41
Multiple generation hh (-1)	-0.0674	-0.84
Δ Other type of hh	-0.0625	-0.74
Other type of hh (-1)	-0.0032	-0.04
Δ Working	-0.1011 **	-2.55
Working (-1)	0.0990	1.60
Δ Secondary job	-0.1011 **	-2.55
Secondary job (-1)	0.0990	1.60
Δ In education	-0.0259	-0.28
Not in education (-1)	0.2079	1.52
Δ Maternity leave	-0.0448	-0.65
Maternity leave (-1)	0.0577	0.69
Δ Unemployed	-0.5362 ***	-11.41
Unemployed (-1)	-0.2842 ***	-3.90
Δ Non-working	-0.0503	-1.54
Non-working (-1)	0.1515 ***	2.96
First stage regression Δ income		
Δ Ln real matched hheq. Income	0.0249 ***	8.61
Ln real matched hheq. income (-1)	-0.0004	-0.07
First stage regression income (-1)		
Δ Ln real matched hheq. Income	0.0111 ***	4.51
Ln real matched hheq. income (-1)	0.0518 ***	8.09
Number of observations	99,283	
Number of individuals	12,507	
F-statistic first stage Δ income	30.30 ***	
F-statistic first stage income (-1)	74.28 ***	

Source: Own calculations. Equations are estimated by OLS with individual fixed effects. They include one-year-lagged year dummies, one-year-lagged state-specific time trends, and current first differences and past levels of state dummies. Hheq.=household equivalant. Hh= household. Robust t-tatistics are clustered for person number. * indicates significant at the 10 percent level, ** at the 5 percent level and *** at the 1percent level.

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Eidesstattliche Erklärung

Ich erkläre hiermit an Eides statt, dass ich die beiliegende Doktorarbeit „Internal Migration, Environmental Amenities and Life Satisfaction: Theoretical Linkages, Empirical Evidence and Methodological Advances“ selbstständig und ohne fremde Hilfe angefertigt habe und dass ich alle von anderen Autoren wörtlich übernommenen Stellen, wie auch die sich an die Gedanken anderer Autoren eng anlehenden Ausführungen meiner Arbeit, besonders gekennzeichnet und die Quellen nach den mir angegebenen Richtlinien zitiert habe.

Frankfurt am Main, den 10.08.2015

Angela Faßhauer

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