Domain-specific risk and public policy‡

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Abstract

We develop a novel method to estimate domain-specific risk. We apply the method to sickness insurance by fitting a utility function at the individual level, using European and UK survey data on life satisfaction. Four results stand out. First, marginal utility is higher in the sick state, conditional on income, due to a fixed cost of sickness. Second, relative risk aversion increases with income. Third, the domain-specificity of risk shifts the focus to the smoothing of utility, not consumption. Fourth, the optimal policy rule implies that the replacement rates are not generally linear.

Keywords: social insurance, sickness absence, state-dependence, risk aversion, behavioral economics

JEL classification: H55, I13, D91

ǂ Financial support from the Academy of Finland Strategic Research Council project Work Inequality and Public Policy (number 293120) and NORFACE (project number 465-13-186) is gratefully acknowledged. We thank Jon Gruber for comments. We also thank Pasi Niskanen for discussions on the ω parameter. We thank participants at XXX Annual Conference of the Italian Society of Public Economics and the IIPF annual meeting for comments, including Matthew Rablen, and Daniel Mahler for his help with the British Household Panel Survey.

1. Introduction

The standard expected utility theory states that the utility gain of consumption smoothing stems from the curvature of the utility function, which governs all states of the world. However, a burgeoning literature in psychology and behavioral economics argues that the value of insurance varies greatly depending upon the context (Weber et al., 2002).

We bridge the gap between these two seemingly incompatible approaches by employing a utility function in which risk is domain-specific. We specify a two-step characterization of income risk with respect to the realization of a domain-specific event. The first step involves studying the change in utility given the curvature of the utility function and a fall in consumption. The crucial new second step is the effect that results from the state-dependence of the utility function.

To operationalize our approach, we study optimal sickness insurance schemes. Sickness absenteeism is an important policy domain, causing a loss of nearly 10% of annual working days in some OECD countries (DICE Database, 2017) and functioning as a pathway to disability (Kivimäki et al., 2004). We allow for a fixed cost of sickness that directly affects utility and changes the relative risk aversion and marginal utility of the utility function. We show that our method leads to a domain-focused view on risk. The relevant domains are defined by stochastic events such as sickness, disability and unemployment, whose implications are mitigated by public policy tools.

One can infer risk preferences and state-dependence empirically by studying individuals' revealed preferences (e.g., Cohen and Einav, 2007) or by analyzing subjective well-being in different states (Finkelstein et al., 2009; Mata et al., 2018). We take the latter approach. We use comprehensive survey data on life satisfaction in Europe (EU-SILC) and panel data from the UK to estimate state-dependent utility functions for the employed and sick leave states. The panel data allow us to assess the potential scope for selection into sickness. A mapping of equivalized disposable income on life satisfaction, as shown in Figure 1 both in cross-section (Panel A) and panel (Panel B), immediately reveals three qualitative results concerning the sickness absence state. First, life satisfaction in the sick state is lower conditional on income. Second, marginal utility in the sick state is higher (i.e., a positive state-dependence). There is also a clear convergence in life satisfaction between the two states at high levels of income. Third, Panel B shows that life satisfaction conditional on income is lower in the subset of the population that has sickness absences during the panel (‘switchers’) relative to those who are never on sick leave (‘non-switchers’). In our formal econometric specification in a cross-section, we employ a two-stage switching regression to account for such observed and unobserved selection bias.

[Figure 1 here]

Our analysis builds on the assumption that life satisfaction approximates utility. The fitted functional form utilizes minimal restrictive assumptions and allows us to identify the relevant parameters of the utility function, including the fixed cost of sickness term. The estimates show that the domain-specific fixed cost plays a fundamental role when characterizing optimal social insurance, particularly at the lower tail of the income distribution.

The empirical findings support our method of incorporating the standard utility theory and insights from recent behavioral economics research. The estimate of the utility function under the employment (i.e., non-sick) state conforms to the standard utility function. However, allowing for and empirically finding a significant difference in the utility curve for those who are on sick leave emphasizes the importance of state-dependence in risk.

Received economic theory argues that the optimal policy rule in sickness insurance schemes constitutes a trade-off between benefits (i.e., the consumption smoothing effect) and costs (i.e., due to hidden actions or the moral hazard effect). The canonical Baily-Chetty formula is based on a state-independent utility function (Baily, 1978; Chetty, 2006, 2008). We relax this restriction and show that the standard measure of relative risk aversion is empirically lacking and that the fixed cost of sickness drives a substantial part of the effect of sickness leave on utility. The last point also implies that social insurance schemes must be calibrated according to our best empirical understanding of utility and risk in each domain.

Our results are relevant for the core features of sickness absence policies. Four points stand out. First, we contribute to the debate of state-dependence by showing that marginal utility is higher in the sick state, conditional on income, due to an estimable fixed cost of sickness. Second, we establish that contrary to conventional wisdom, relative risk aversion increases with income. Third, the focus has traditionally been on consumption smoothing because consumption and the curvature of the utility function are the sufficient statistics in the received view to understand the benefit of the insurance. However, the domain-specificity of risk requires a more specific understanding of utility of the sick versus employed states, shifting the focus to the smoothing of utility, not consumption. Fourth, the optimal policy rule shows that the replacement rate decreases slightly with income. The estimated fixed cost of sickness reshapes the replacement rate curve from increasing to decreasing, in spite of our estimate of increasing relative risk aversion with income.

Concerning sickness, the assumption of state-independence of the utility function has been challenged by previous contributions. The empirical literature provides conflicting results concerning whether the marginal utility is higher or lower for the sick population (see Finkelstein et al., 2009, p. 117; see also Viscusi and Evans, 1990). The empirical literature on insurance choice in economics along with the psychological literature has found that risk taking is highly domain-specific (Einav et al., 2012; Weber et al., 2002). A notable difference between our measure and the previous psychological contributions is that in our measure, the focus is on the population level, not the individual level, because public policy is conditioned on a single state parameter, namely sickness.

Using US data, Finkelstein et al. (2013) estimate that a one standard deviation increase in the incidence of chronic disease leads to a 10%–25% drop in the marginal utility of consumption relative to the healthy population. Their result is thus opposite to ours. There are a few possible reasons for such a deviation. First, they study the effect of chronic conditions, whereas we study sickness absence. Second, their main specification is a log-linear mapping from income to well-being, i.e., Finkelstein et al. (2013) assume a relative risk aversion of 1, although they find that their result is robust to some relaxation of this assumption. Conversely, we focus on a non-linear specification in which we estimate risk aversion (which is non-constant by income), the level effect of sickness and the fixed cost of sickness. Their functional form is thus a special case of the one we utilize. However, replicating their specification (Finkelstein et al., 2013, p. 236) by replacing the number of diseases with a sickness absence dummy with our main dataset, we obtain a statistically insignificant result with an opposite point estimate to theirs (not reported). Third, their response variable is a binary happiness indicator, as opposed to our cardinal measure of life satisfaction. Fourth, the two studies focus on contrasting populations. Finkelstein et al. (2013) study those aged above 50 who are not in the labor force. We study working-age employed population.

The paper is structured as follows. Section 2 discusses the key theoretical aspects of an optimal sickness insurance system. Section 3 describes EU-SILC and UK data and characterizes the utility function and empirical estimation methods. Section 4 reports the estimation results. The last section concludes.

2. Optimal sickness insurance

We apply and develop the static Baily-Chetty approach to sickness insurance (Baily, 1978; Chetty, 2006; Chetty and Finkelstein, 2013). The theoretical model describes a welfare-maximizing social planner's optimal choice of sickness benefits and taxes given the costs and benefits of a higher sickness allowance for a utility-maximizing representative agent who chooses the length of the sickness absence spell. The costs of higher replacement rates consist of unobservable hidden actions, the effect of longer sickness spells at the intensive margin and more sickness spells at the extensive margin. The benefit is the utility smoothing across states that is provided by sickness insurance.[1]

We make two important departures from the standard theoretical model, as outlined by Chetty (2006). Both aspects are crucial for estimating and designing the optimal policy. On the cost side, we explore the relative contribution of the extensive and intensive margins by allowing the probability of becoming sick to vary in the model as a function of effort, which is unobservable to the social planner. On the benefit side, we allow for a fixed cost of sickness (θ in the model), i.e., we depart from the standard assumption of the state-independence of the utility function.[2]

The fixed cost of sickness, which fundamentally affects the utility gain of consumption smoothing, could in principle be of either sign. The fixed cost of sickness being positive (negative) implies a positive (negative) state-dependence, meaning that the marginal utility is

[1] Our approach emphasizes the smoothing of utility rather than consumption across the states.

[2] See Chetty and Finkelstein (2013, pp. 155-156) for an alternative way to incorporate state-dependence.

higher (lower) in the sick state. The importance of state-dependence in optimal sickness insurance has been acknowledged since at least Zeckhauser (1970) and Arrow (1974). The prior evidence (see Finkelstein et al., 2009, for a review), however, focuses on the relationship between health (e.g., Finkelstein et al., 2013, study chronic disease) and marginal utility. Our focus is on the relationship between sickness absence status and marginal utility. In what follows, we characterize and estimate θ.

The model yields an implicit equation for the optimal benefit, *b*, which is based on the sufficient statistics approach (an augmented Baily-Chetty formula; see Appendix 2 for the detailed derivation of the model):

$$\varepsilon_{r,b} + \varepsilon_{D,b} = \frac{u'(c_s,1) - u'(c_e,0)}{u'(c_e,0)} \approx \gamma \frac{\Delta c + \theta}{c_e}\left[1 + \frac{1}{2}\rho\frac{\Delta c + \theta}{c_e}\right], \tag{1}$$

where $u(c_e, 0)$ and $u(c_s, 1) = u(c_s - \theta, 0)$ are the utility functions and c_e and c_s are consumption in the employment ($S = 0$) states and sickness leave ($S = 1$), respectively; $\frac{\Delta c}{c_e} = \frac{c_e - c_s}{c_e}$ is the proportional drop in consumption when on sick leave; $\gamma = -\frac{c_e u''(c_e)}{u'(c_e)}$ is the coefficient of relative risk aversion; $\rho = -\frac{c_e u'''(c_e)}{u''(c_e)}$ is the coefficient of relative prudence; $\varepsilon_{r,b} = \frac{d\log(\frac{p}{1-p})}{d\log(b)}$ is the elasticity of the odds ratio ($r = \frac{p}{1-p}$) of sickness leave with respect to the sickness benefit, i.e., the extensive margin; and $\varepsilon_{D,b} = \frac{d\log(D)}{d\log(b)}$ is the elasticity of the duration (*D*) of sick leave with respect to the sickness benefit, i.e., the intensive margin. The envelope theorem guarantees that all other behavioral responses can be ignored when setting the optimal benefit level, except for the elasticity parameters ($\varepsilon_{D,b}$ and $\varepsilon_{r,b}$) that enter the government budget constraint directly.

The model has an intuitive interpretation. The right-hand side of equation (1) defines the value of the insurance, i.e., the change in relative marginal utility, and the fixed cost of sickness under sick leave. The reduction in consumption is a function of the replacement rate, i.e., the rate at which pre-sickness income is covered by the sickness insurance scheme (for more details, see Section 3). We estimate the utility function parameters, including the fixed cost of sickness, allowing the value of insurance to vary as a function of income.

The left-hand side of the equality in equation (1) disentangles the extensive ($\varepsilon_{r,b}$) and intensive ($\varepsilon_{D,b}$) margins of the effect due to hidden actions. In our formulation, the extensive margin is expressed using the odds ratio $r = \frac{p}{1-p}$, following discrete choice models.

The Baily-Chetty formula is based on simplifying assumptions. The model does not account for possible preference for vertical redistribution across individuals, general equilibrium effects on wages, the marginal cost of public funds, externalities on government budget or other externalities (Pichler and Ziebarth, 2017). Reference-dependence might play a role in the utility function in this context. However, the part of reference-dependence that is not captured by θ is not considered.

3. Empirical approach

3.1. Data

We use the EU Statistics on Income and Living Conditions (EU-SILC) data. The EU-SILC is a harmonized dataset on income, social inclusion and living conditions that covers the material and subjective aspects of well-being.[3] The EU-SILC data are based on a combination of survey and register-based information, depending upon the source country. We use the data for all 27 countries that were members of the European Union in 2013 (see Appendix 3 for a description of sickness insurance institutions in Europe). In addition, we use data on Iceland, Norway and Switzerland, for a total of 30 countries.

Descriptive statistics are presented in Table 1. Figures A1–A2 display the histograms of the incomes and life satisfaction of the two subsamples (being on sick leave vs. employed), respectively. The subsample that is employed is large (~125,000), whereas the subsample for those on sick leave is substantially smaller (~1,200). Mean life satisfaction is ~0.8 points lower for those on sick leave, a difference that echoes the well-being gap between the employed and the unemployed (Clark and Oswald, 1994).

[Table 1 here]

We use four variables to construct our estimates. To define the working population, we restrict the sample to those aged 18 to 64 who work more than 30 hours per week (the variable PL060 in EU-SILC). We define the sick leave population as those who work less than 30 hours per week due to "disability or illness" (PL120). Our preferred measure of subjective well-being is life satisfaction. It is the best available measure of utility (Benjamin et al., 2012; 2014a-2014b). We use the standard life satisfaction question (PW010): "Overall, how satisfied are you with your life nowadays?" The level of life satisfaction is measured on an eleven-point scale from 0 to 10, where 0 is 'not at all satisfied' and 10 is 'completely satisfied'. We give the life satisfaction variable a cardinal interpretation to accomplish our

[3] See http://ec.europa.eu/eurostat/web/income-and-living-conditions/overview. The data are public available to other researchers subject to following the EU procedures, and our method is replicable for sickness insurance and other domains.

analyses, following, e.g., Layard et al. (2008). For income, we use PPP-adjusted equivalized disposable household income per consumption unit (HX090).

To mitigate potential selection bias, we also study panel data. For that purpose, we use British Household Panel Survey (BHPS) data from 1995–2008.[4] For life satisfaction, respondents are asked, “How dissatisfied or satisfied are you with your life overall?" on a seven-point scale from 1 ‘not satisfied at all’ to 7 ‘completely satisfied’. See Table 1 (Panel B) for descriptive statistics. To identify the employed population, we select those who said they ‘did paid work last week’ (variable “jbhas”). The sick leave population consists of those who said the ‘main reason that [they] were away from work last week’ was sickness or injury (variable “jboffy”). Income is household annual net income per consumption unit.

3.2. A utility function compliant with data

We estimate utility functions in the states of employment and sickness using life satisfaction as a measure of subjective well-being, allowing us to infer both the degree of risk aversion and state-dependence. There is no consensus on the sign of state-dependence, possibly due to varying contexts (see Finkelstein et al., 2009; Finkelstein et al., 2013; Figure A3).

For a non-parametric analysis of the relationship between income and life satisfaction in the data, we fit a spline. A visual inspection of the fit as shown in Figure 1 reveals that the utility of sick leave is lower with a higher slope, compared with those who are employed. To account for such a relationship, we utilize a function in the family of HARA (Hyperbolic

[4] The German Socio-Economic Panel would have offered a larger sample size, but it does not allow for a clear identification of those on sickness absence.

Absolute Risk Aversion) utility functions, with relative risk aversion increasing, decreasing, or constant (see Merton, 1971; Meyer and Meyer, 2005, for a review):

$$u(c(y), S) = \frac{\gamma}{1-\gamma}\left(\frac{\alpha_H y - \omega - \theta S}{\gamma}\right)^{1-\gamma}, \tag{2}$$

where S is an indicator for sickness leave, and ω is a shift parameter that has been used in dynamic analyses incorporating stock effects, such as habit formation; see Phlips (1978). As in the economic model presented in Section 2, θ is the fixed cost of sickness. The HARA family offers a flexible and tractable functional form that encompasses the most commonly used functions in macroeconomics and finance and emerges from economic reasoning (Perets and Yashiv, 2016). For simplicity, we set the income scale parameter $\alpha_H = 1$ (see Section 3.3. for more details).

Unlike in the standard CRRA (Constant Relative Risk Aversion) model, the relative risk aversion (RRA) and relative prudence (RP) are functions of y and ω. Assuming that agents also know their utility function in the sick state and optimize their utility across the states, their relative risk aversion and relative prudence are also functions of θ:

$$RRA_S(y, 1) = -y\frac{u''(y,1)}{u'(y,1)} = \frac{\gamma y}{y-\omega-\theta}, if\ c > \omega + \theta \tag{3}$$

$$RP_S(y, 1) = -y\frac{u'''(y,1)}{u''(y,1)} = \frac{(\gamma+1)y}{y-\omega-\theta}, if\ c > \omega + \theta. \tag{4}$$

In fact, using the functional form from equation (2) and assuming that equivalized disposable income is a near equivalent to consumption (but see equation (13)), we can explicitly solve equation (1) for the optimal replacement rate (RR):

$$RR = 1 - \frac{\Delta y}{y_e} = \left(\frac{\omega}{y_e} + \frac{\theta}{y_e}\right) + \left(1 - \frac{\omega}{y_e}\right)\left(1 + \varepsilon_{r,b} + \varepsilon_{D,b}\right)^{-\frac{1}{\gamma}}, \tag{5}$$

where $\Delta y = y_e - y_S$. Equation (5) yields the optimal benefit schedule in terms of replacement rates conditional on the income level. Note that the presence of θ on the right-hand side of equation (5) implies that pecuniary and non-pecuniary costs must be considered when characterizing the total benefit of insurance. If $\theta > 0$, the state-dependence is positive and *vice versa.*

3.3. Baseline estimation

For the empirical specification of the utility function, we estimate a least squares fit of the following form:

$$SWB(c(y_i), S_i) = \alpha + \frac{\beta}{1-\gamma}\left(\frac{y_i - \omega - \theta S_i}{\gamma}\right)^{1-\gamma} + \delta S_i + \varepsilon_{S_i,i}, \tag{6}$$

which is equation (2) augmented with additional parameters (α and δ) to increase flexibility. S_i is the sickness leave indicator, δ is the level effect of sickness absence, y_i is equivalized disposable income, and SWB_i is life satisfaction. Sickness ($S_i = 1$) is measured as the state of working under 30 hours per week due to sickness. Employment ($S_i = 0$) is measured as the state of working more than 30 hours per week. The parameters α and β¸ whose values are not our focus, are included to account for the scale used to measure life satisfaction. Note that parameters α, β and δ do not affect the relative marginal utilities in equation (1).

We apply the R package “minpack-lm”, which is based on a modified Levenberg-Marquardt-type algorithm to obtain our fit. The maximizing problem is non-smooth across the boundary of having the value one in the γ parameter. We choose the fit with the lowest sum of squared errors across the regions, which is obtained with an above-one initial γ parameter value.

If $\gamma > 1$ equation (6) yields a bounded utility function. Since the data have a natural upper bound of 10, we estimate the model assuming that $\alpha = 10$. For completeness, the state-dependent level parameter δ is included to guarantee $SWB(S=0) > SWB(S=1)$ in the case of negative state-dependence, $\theta < 0$.

The functional form (6) corresponds to HARA $\left(U_{HARA}(c(y)) = \frac{\gamma}{1-\gamma}\left(\frac{\alpha_H y+\beta_H}{\gamma}\right)^{1-\gamma}\right)$, with the simplifying restriction that $\frac{\alpha_H}{\gamma} = \frac{1}{1000}$, i.e., we measure income in thousands of annual euros. Scaling income to a similar order of magnitude as life satisfaction slightly increases estimation robustness, due to particulars of the numeric estimation algorithm. The numerical values of the parameters of interest $\{\theta, \omega\}$ remain stable but are scaled by $\frac{1}{1000}$, and the estimation of the crucial parameter γ is not qualitatively affected by the scale.

Empirically, at any point in time, we assume there is a difference in the marginal utility of the employed ($S=0$) and sick leave ($S=1$) populations that is driven by the fixed cost of sickness (θ). The parameter θ can be decomposed into two parts, $\theta = \theta_s + \theta_b$, where θ_s is the effect of sickness absence across states and θ_b is the difference in the utility across individuals. The latter component is the selection bias. For the policy to be pure insurance, the social planner will only consider θ_s. To maximize utility across states and across individuals, the social planner will consider both components. A cross-sectional analysis would identify the sum of the two, whereas a causal analysis of sickness absence will only identify θ_s.

3.4. Switching regression

In the cross-sectional data, our model assumes that the regression compares essentially 'same individuals' across the income distribution and the two states. To test the robustness of our model to and to correct for selection bias, we utilize a two-stage switching regression model with endogenous selection across states, in which we initially estimate a probit model for the selection function in the two states (equations 8 and 9) and then proceed to estimate the non-linear utility function with the correction terms for the selection bias (equation 10) to equation (7). We consider selection with respect to sickness absence and predetermined levels of equivalized disposable income.

First, consider selection with respect to sickness absence state in the model:

$$SWB(c(y_i), S_i) = \alpha + \frac{\beta}{1-\gamma}\left(\frac{y_i - \omega - \theta S_i}{\gamma}\right)^{1-\gamma} + \delta S_i + \varepsilon_{S_i,i}. \tag{7}$$

We introduce a selection function (8) that determines which of the two equations ($S_i = 1 \; or \; S_i = 0$) is applicable:

$$S_i = 0,\ \text{iff}\ Z_i\zeta \geq \upsilon_i \; and \; S_i = 1,\ \text{iff}\ Z_i\zeta < \upsilon_i. \qquad \text{(selection function, 8)}$$

We observe S_i and Z_i, where Z_i is a row vector of covariates, ζ is an estimable column vector of parameters, and υ, the stochastic element of the selection function, is correlated with ε_0 and ε_1. Assuming joint normality of the stochastic elements ($\varepsilon_{S_i}, \upsilon$), one obtains a probit model to estimate ζ,

$$P(S_i = 1) = \Phi(Z'_i\zeta), \tag{9}$$

and state-dependent correction terms for selection bias,

$$E\left(\varepsilon_{1,i} \middle| Z'_i\zeta < \upsilon_i\right) = -\sigma_{1,\upsilon}\frac{\phi(Z'_i\zeta)}{\Phi(Z'_i\zeta)} \text{ and } E\left(\varepsilon_{0,i} \middle| Z'_i\zeta \geq \upsilon_i\right) = \sigma_{0,\upsilon}\frac{\phi(Z'_i\zeta)}{\Phi(-Z'_i\zeta)}, \tag{10}$$

where $\sigma_{1,\upsilon}$ and $\sigma_{0,\upsilon}$ are unknown covariances of υ with the error terms ε_S, $S \in \{0, 1\}$. The covariances are estimated in the second stage by adding the relevant correction terms to the RHS of equation (7) (for details, see Maddala (1983), pp. 223–228). For the model to identify the unbiased parameters, we assume that it accounts for unobserved heterogeneity and is not driven by reverse causality.

We also consider selection with respect to a cut-off point ($\bar{Y}$) that is a predetermined level of income:

$$SWB(c(y_i), S_i, \bar{Y}_i) = \alpha + \frac{\beta}{1-\gamma}\left(\frac{y_i-\omega-\theta S_i}{\gamma}\right)^{1-\gamma} + \delta\bar{Y}_i + \varepsilon_{\bar{Y},i}, \tag{11}$$

where $\bar{Y}_i = 1\ iff\ \ y_i > \ \bar{Y}$. Otherwise, the procedure is analogous to equations (7–10). We have used median income as a cut-off point but using the first or third quartile yields similar results.

3.5. Replacement rate: income vs. consumption

We use equivalized disposable income to approximate consumption as closely as possible with an income measure to explicitly solve for optimal replacement rates; see equation (3). Not using actual consumption levels induces a potential bias (see Gruber, 1997; Kolsrud et al., 2018).[5] However, assuming that our equation (6) uncovers marginal utilities conditional on income levels in the sick and employed states, we have

$$u'(y, S) = u'(c(y), S)c'(y, S) = SWB'(c(y), S)c'(y, S) = \beta(y - \omega - \theta S)^{-\gamma}. \tag{12}$$

Note that equation (12) is a function of y, not of c.

[5] The bias is due to additional hidden effects, which affect consumption rates, i.e., the increase in benefits crowding out savings (Engen and Gruber, 2001) or spousal labor supply (Cullen and Gruber, 2000). However, in the case of sickness insurance, these costs are negligible in comparison with old age insurance and smaller than in the case of unemployment insurance For an analysis of old age insurance, see Feldstein (1974).

More generally, we can calibrate the optimum (equation 1) in terms of our observables using $u'(y,S) = u'(c(y),S)c'(y,S)$ and a linear approximation to $c'(y_s,1) - c'(y_e,0)$ to obtain

$$\varepsilon_{r,b} + \varepsilon_{D,b} = \frac{u'(c_s,1) - u'(c_e,0)}{u'(c_e,0)} = \frac{(c'(y_e,0)/c'(y_s,1))u'(y_s,1) - u'(y_e,0)}{u'(y_e,0)}$$

$$\approx \gamma \frac{\Delta y + \theta}{y_e}\left[1 + \frac{1}{2}\rho \frac{\Delta y + \theta}{y_e}\right] - \frac{c''(y_s,1)y_s}{c'(y_s,1)}\frac{\Delta y}{y_s}\left[1 + \gamma \frac{\Delta y + \theta}{y_e}\right], \qquad (13)$$

where $c''(y_s,1)y_s/c'(y_s,1)$ is the elasticity of marginal propensity to consume. Assuming Keynesian consumption functions that allow the constant term to be state-dependent, $c(y,S) = c_0(S) + c_1 y$, giving $c''(y_s,1) = 0$; $c'(y_e,0)/c'(y_s,1) = 1$, and the last term on the RHS of (13) is equal to zero. Note that equation (6) estimates γ and ρ as risk parameters relative to income, not to consumption. Chetty and Finkelstein (2013) argue that these parameters are likely to vary with *b*, which would provide an alternative approximation to that of Gruber (1997) in terms of observable variables. Strictly speaking, our local recommendations concerning policy are based on the first-order conditions (Appendix 2). Since parameters can vary with policy rule, they might not apply globally.

4. Results

4.1. Main specification and implications for policy design

To model the empirical relationship observed in Figure 1 and to obtain the numerical estimates of the parameters of the utility function, including the fixed cost of sickness, we fit equation (6). The estimated parameter values are documented in Table 2. The result is presented in column 1 of Table 2, in which we set $\alpha = 10$. The estimated values ($\gamma > 1$) imply that $\lim_{c\to\infty} LS(c) = 10$, where *LS(c)* is life satisfaction as a function of consumption. The parameters with policy significance, $\{\gamma, \theta, \omega\}$, are all statistically highly significant.

The resultant utility curves, overlaid on the spline fit, are presented in Figure 3. The estimates confirm the visual observation that the association between life satisfaction and income is steeper, conditional on income in the sickness absence state. Using our functional form, the positive state-dependence stems from the positive and significant fixed cost of the sickness parameter, θ. Visually, the difference in the slopes of the spline curves is at its largest at low incomes. However, dropping observations at incomes below 5,000 euros or above 80,000 euros in Panel A does not have a large impact on the parameter estimates (not reported).

Columns 2 and 3 of Table 2 present the switching regression results. We consider column 2 as the main specification, in which we correct for selection with respect to the sickness state. The estimates are similar in all models for γ and ω. The fixed cost of sickness (θ) in column 3 is significantly lower than in column 1 and 2, and the level effect of sickness (δ) differs across all models. The estimated covariances of selection ($\sigma_{1,v}$ and $\sigma_{0,v}$) in columns 2 and 3 are statistically significant, suggesting presence of selection bias in column 1. A positive point estimate for the sick state ($\sigma_{1,v}$) implies that the correction term in equation (10) is negative,

$$E\left(\varepsilon_{1,i} \middle| Z'_i\zeta < v_i\right) = -\sigma_{1,v}\frac{\phi(Z'_i\zeta)}{\Phi(Z'_i\zeta)},$$

i.e., those in the sick state have an error term with a negative mean in their utility function. The correction term can also affect the form of the utility function, since it varies by individual.

We estimated the model for the BHPS panel for the switchers (see Figure 1 for the definition) to further explore the effect of selection bias on the estimates. We allow the α parameter to vary in the estimations, since a fixed value of 7 would cause the estimation to diverge. Column 4 presents the estimates from the model. Few parameters are significant, but the point estimates generally align with the estimates from EU-SILC.

Given the estimated utility function in the main specification (Table 2, column 2), we calculate the relative risk aversion and relative prudence parameters using equations (3) and (4), respectively. The estimated relative risk aversion increases with income, as presented in Figure A4 in the employed and sick states. This result challenges the conventional wisdom (see Meyer and Meyer, 2005). However, coupled with the fixed cost of sickness, the utility loss of sickness is higher for low-income earners. As argued above, in our application, the emphasis is on the estimate for the sick state, in which relative risk aversion is higher.

[Table 2 and Figure 3 here]

To complete the analysis, we assume that $\varepsilon_{r,b} + \varepsilon_{D,b} = 1.5$. Thus, the combined effect of the extensive and intensive margins sums to 1.5. Böckerman et al. (2018) find that $\varepsilon_{D,b} \approx 1$.[6] There are no comparable estimates for the extensive margin in the literature using nationally representative settings. We assume that $\varepsilon_{r,b} = 0.5$, giving a total of 1.5. A higher elasticity yields a lower optimal replacement rate, and we remain cautious about the exact magnitude of the elasticity. We apply equation (3) to study the optimal replacement rates given the estimated and assumed parameter values. We are also interested in the role of θ in determining the optimal policy curve (Figures 4–5).

[Figures 4–5 here]

[6] Echoing the estimate that we use in the calculations, Ziebarth and Karlsson (2014) argue that the consensus estimate of the literature is ~1.

We find that the optimal replacement rate curve is non-linear and decreases slightly with income. In Figure 4, we show that the fixed cost of sickness reshapes the replacement rate curve from increasing to decreasing, in spite of our estimate of increasing relative risk aversion with income. A key feature is that relative risk aversion is higher in the sick state.

Figure 5 shows the optimal policy curve. Our estimated replacement rates for most income earners fall close to the current French policy. Note, however, that the optimal curve is based on equivalized disposable income, whereas the current policy schemes are based on earnings. Therefore, our analysis follows the literature in abstracting from sources of income other than labor income and income of other family members. A similar observation holds true for any effects that operate through the savings rate.

4.2. Country-level analysis and other domains

We replicate the aggregate analysis at the country level. The fits are shown in Figure A4.1. See Appendix 4 for technical details. The functional fit follows the pattern of the aggregate fit remarkably well given the lower sample size for each country. The estimation of ω is robust to the exclusion of low-income individuals in the data because the whole range of incomes is used for the estimation. However, the non-parametric spline is highly inaccurate for most countries.

We extract the ω parameter point estimates from the country-level fits and correlate them with the measures of institutions (Figure A4.2). The ω parameter is equivalent to giving each citizen an equal increase in consumption, increasing utility at all consumption levels. The ω parameter, which measures this shared increase in utility, captures the value of *all* of the characteristics of a country, including for example its institutions, social norms, culture, and geographical features. For brevity, we call ω the institutions parameter. In contrast to Jones and Klenow (2016), the ω parameter abstracts from consumption levels.

We find that the Nordic welfare states have a high ω. By contrast, high-income Southern European countries have a low ω. The high correlation coefficient between the institutions parameter and trust is notable, at 0.80 for interpersonal trust and 0.82 for the mean trust in the police, the legal system and the political system. Additionally, the Gini coefficient of equivalized disposable income has a highly significant correlation with the institutions parameter, at -0.59. The high correlations suggest that the institutions parameter captures something that is of real world significance. However, one should interpret numeric values with caution, even when the rankings and relative values appear to matter.

The sickness benefit can affect the value of institutions and the functional form between income and life satisfaction across countries. However, the correlation coefficient between the replacement rate and the estimated value of institutions is low at 0.20 and not statistically significant. Table A4.2. reports the estimated contribution of institutions and consumption to the mean utility by country.

The domain-specificity of risk implies that each domain must be studied separately for optimal policy design. To illustrate this aspect, we extend the current analysis to the domain of unemployment cursorily in Figure A5. The figure shows that the state-dependent utility appears qualitatively similar to the case of sickness. An analysis of optimal unemployment insurance should thus follow steps similar to those taken in this paper.

5. Conclusions

To paint a data-driven picture of an important policy issue, we use comprehensive subjective well-being data to measure utility and characterize risk in a domain-specific manner and the implied optimal sickness insurance rules. The representative survey data cover 30 countries in Europe, allowing us to account for institutional variation.

We establish three main results. First, the marginal utility is higher in the sick state, conditional on income (i.e., positive state-dependence), due to a fixed cost of sickness that has a larger effect at lower levels of income. Consequently, the augmented Baily-Chetty model with real-life parameter values implies that optimal policy design has higher replacement rates for low-income individuals than do most policy rules in Europe. This result provides *prima facie* evidence that linear rules are non-optimal. Second, relative risk aversion increases with income.

Our third result is that the domain-specificity of risk implies that the gain from insurance is due to the smoothing of utility, not of consumption, across states. The perspective of utility smoothing is indispensable due to the pecuniary and non-pecuniary costs related to sickness that affect the marginal utility across the states. Other applications could exhibit other forms of costs and benefits, which must be accounted for when studying utility smoothing and insurance.

These results challenge the standard view of risk aversion. Based on our analysis, the relative marginal utility is domain-specific and is driven by the fixed costs of adverse events. The role of optimal public policy is to mitigate this sizable welfare cost, which is more pronounced at lower levels of income.

We propose the following procedure when assessing domain-specific risk. First, estimate the standard measure of relative risk aversion in the state in which risk has been realized. Second, evaluate the utility cost or gain due to the state-dependence of the utility function.

The estimated institutions parameter, which has a marked influence on the shape of life satisfaction curves, captures the effects of predetermined stock variables, such as the value of institutions. We present country-specific estimates of the institutions parameter and report unconditional correlations lending credence to the value of institutions across European countries, such as interpersonal and institutional trust.

To identify utility functions, we assume that life satisfaction is a sufficiently satisfactory measure of utility, and our fit of equation (7) guarantees a sufficiently good fit. In essence, we assume that our regressions compare ‘same persons’ across the income distribution and the two states, given our switching model with endogenous switching between the sick and employed states.

Our results apply to Europe-wide sickness insurance. The estimates based on individual countries are qualitatively similar and offer a future avenue for the study of the value of institutions. Future research should also consider other risks, such as unemployment and old age.

Figures and Tables

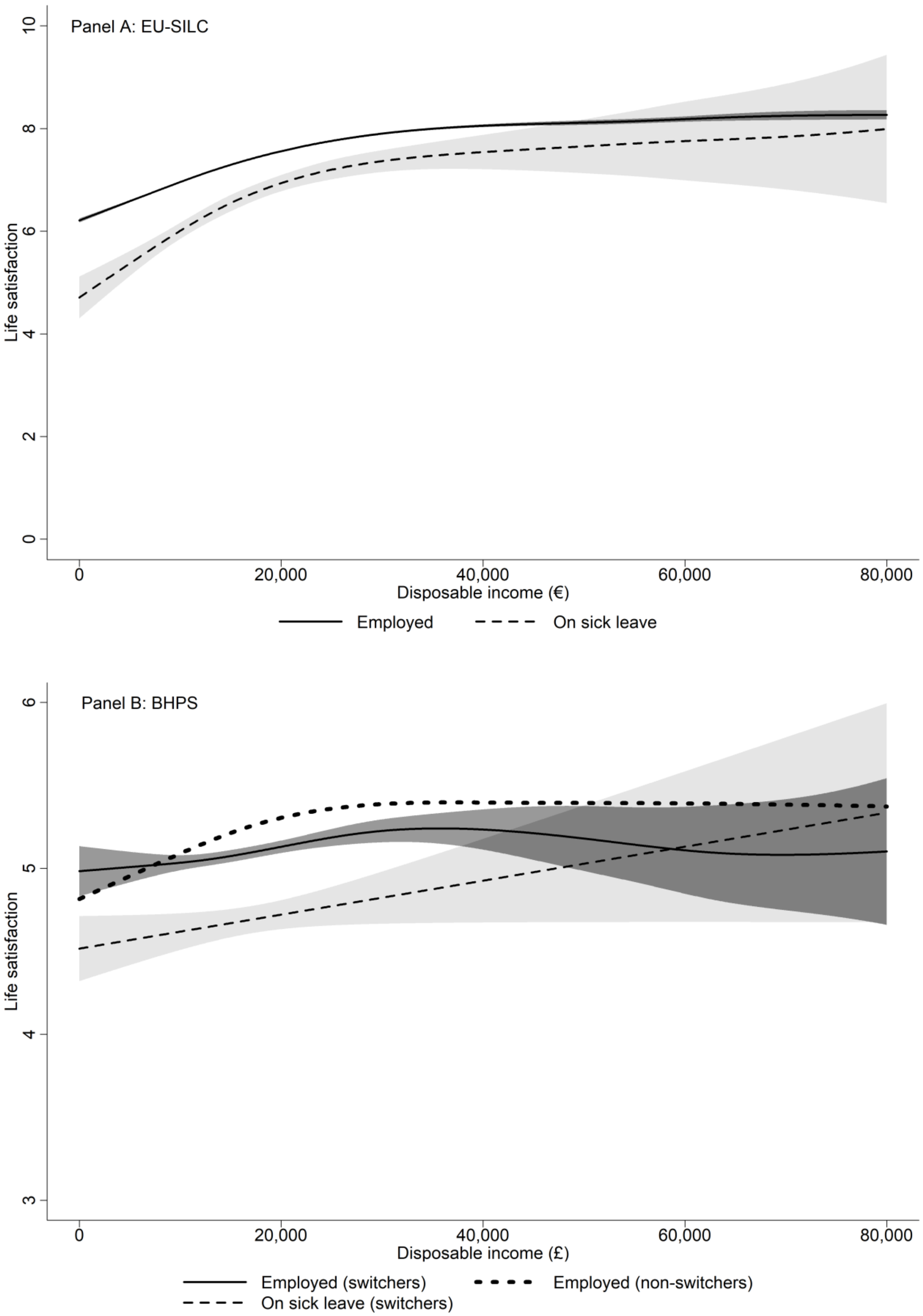
Table 1. Descriptive statistics

Panel A: EU-SILC				
	Employed		On sick leave	
	Mean	SD	Mean	SD
Life satisfaction	7.38	1.79	6.56	2.20
Equivalized disposable income (thousands €)	19.94	15.07	18.39	11.59
Age	43.77	10.77	51.18	8.95
Female	0.45	0.50	0.70	0.46
Tertiary education	0.69	0.46	0.42	0.51
N	125,166	-	1,236	-

Panel B: BHPS						
	Employed ('non-switchers')		Employed ('switchers')		On sick leave ('switchers')	
	Mean	SD	Mean	SD	Mean	SD
Life satisfaction	5.21	1.14	5.06	1.17	4.65	1.45
Equivalized disposable income (thousands £)	18.14	10.59	17.84	8.77	17.61	8.15
Age	40.30	12.73	42.49	10.88	43.18	12.4
N	36,439	-	3,390	-	503	-

Notes. ***Panel B:*** *The numbers are calculated for each person-year observation for which a positive weight is calibrated. 'Switchers' are those who had 1 or 2 periods on sick leave throughout the panel but were employed the rest of the periods. 'Non-switchers' were employed throughout the panel.*

Figure 1. Spline fit of life satisfaction and income in Europe and UK, employed vs. sick



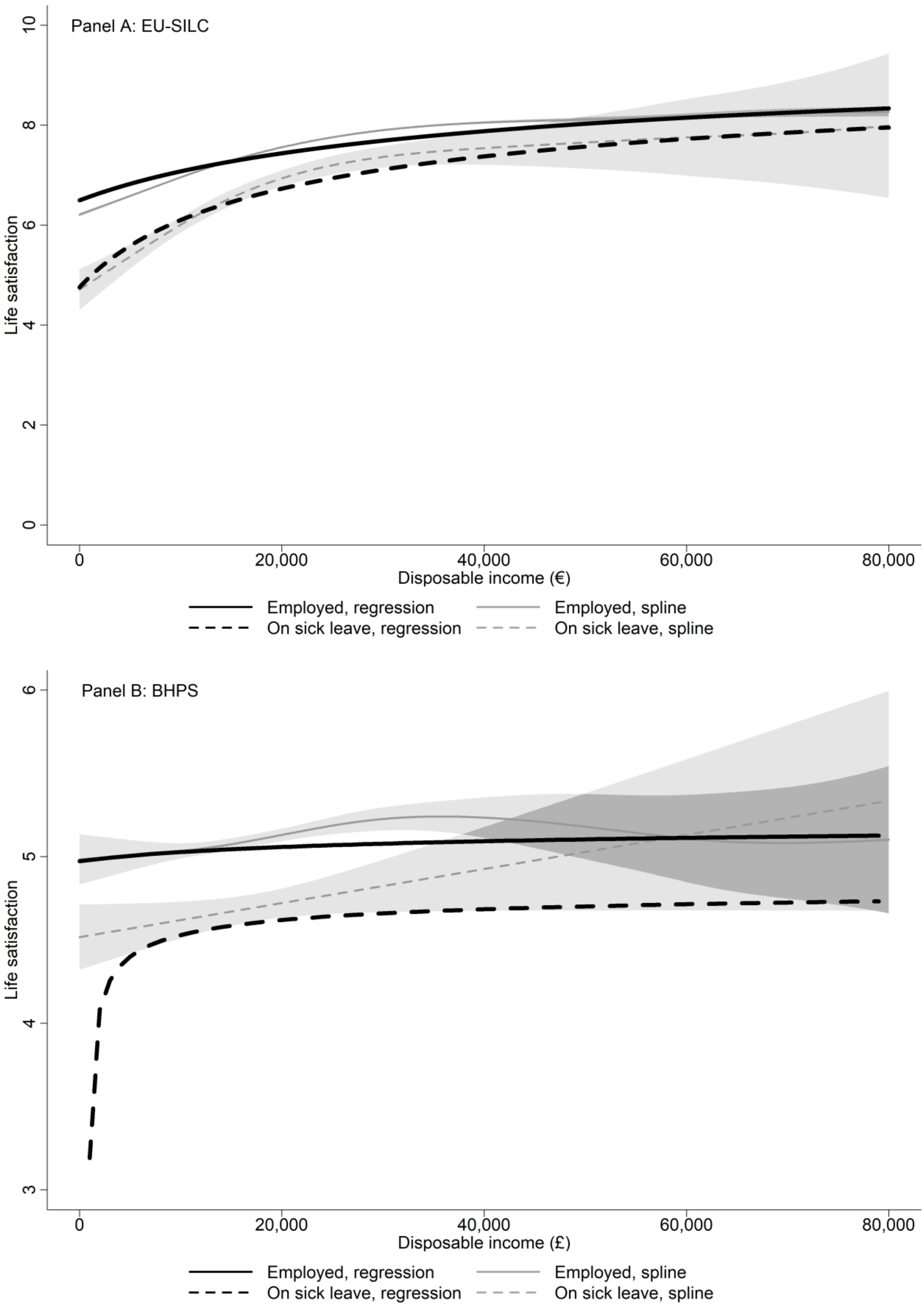
Notes. The estimate is a cubic spline with six knots estimated with the R package "bigsplines" using the default parameter values. ***Panel A.*** *The gray area around the curves represents the 95% confidence interval. Sample size: 125,166 in employment, 1,236 on sick leave.* ***Panel B.*** *The gray area around the curves represents the 95% confidence interval (omitted and very narrow for non-switchers). "Switchers" signifies those individuals who are both in the employed (3,390 person-year observations) and the sick (503 person-year observations) state throughout the panel window of 13 years. "Non-switchers" (36,439 person-year observations) remain employed throughout the panel.*

Table 2. Estimates

	Least Squares	Switching regression		Least Squares
Data	EU-SILC			BHPS
		<u>**Main specification**</u>		
	Model 1	Model 2: selection w.r.t. sickness absence state	Model 3: selection w.r.t. income above median	Model 4: BHPS for 'switchers'
Constant: α	-	-	-	5.26*** (1.12)
Scale parameter: β	7.85*** (2.10)	4.48*** (0.81)	6.51*** (1.16)	0.34 (1.54)
Relative risk aversion parameter: γ	1.49*** (0.04)	1.36*** (0.02)	1.46*** (0.03)	1.40 (1.67)
Institutions parameter: ω	-22.37*** (3.18)	-18.52*** (2.4)	-15.46*** (1.82)	-14.6 (43.03)
Fixed cost of sickness: θ	11.37*** (1.93)	9.27*** (1.94)	3.34 (2.39)	15.42 (44.19)
Covariance with selection (sick state): $\sigma_{1,\upsilon}$	-	2.49* (1.49)	0.39*** (0.14)	-
Covariance with selection (employed state): $\sigma_{0,\upsilon}$	-	0.28*** (0.01)	0.26*** (0.01)	-
Level effect of sickness: δ	-0.28** (0.12)	0.30* (0.16)	-0.95*** (0.26)	-0.38* (0.21)
N	126,402	126,402	126,402	3,893

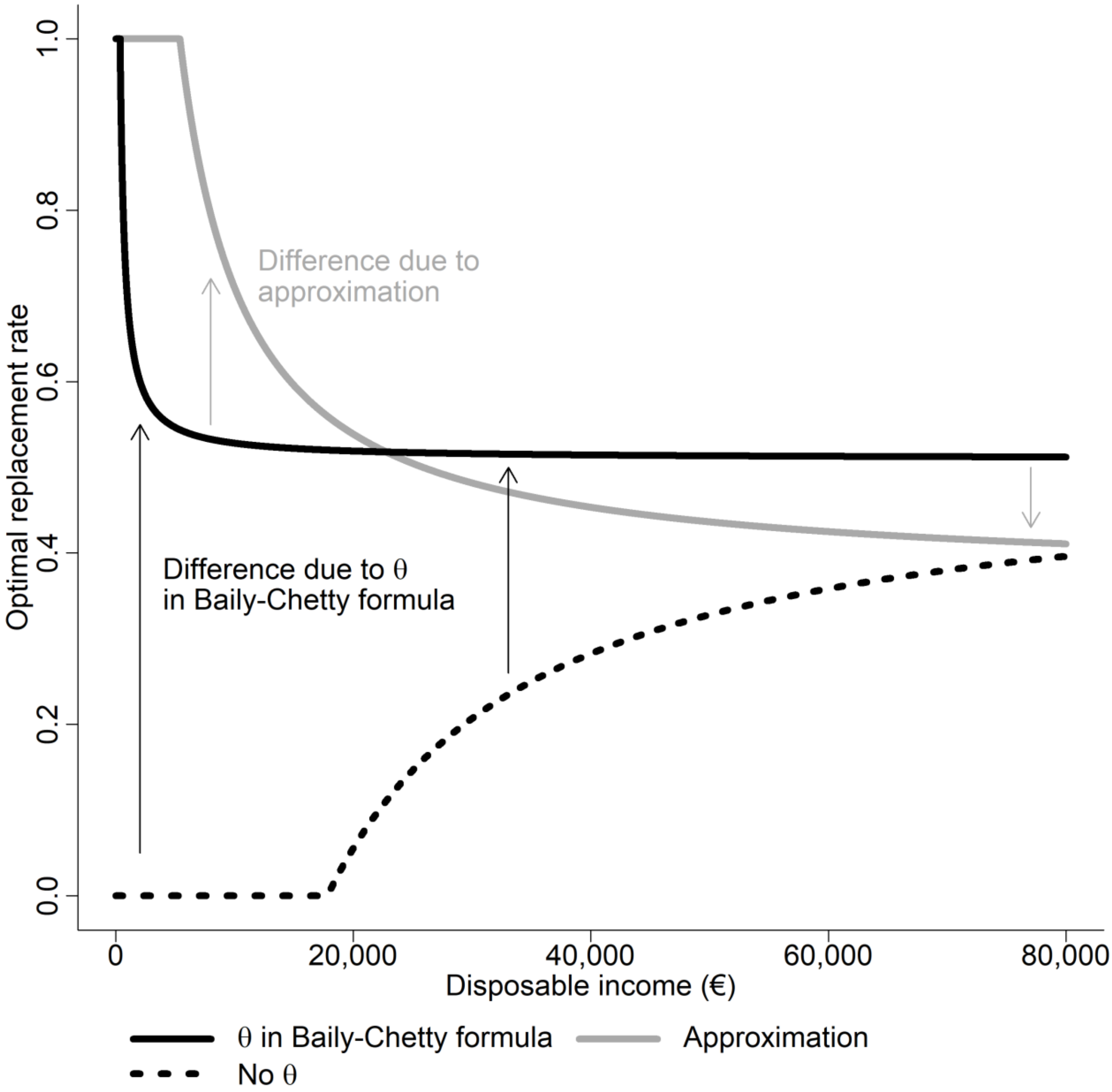
*Notes. Statistical significance: * p<0.1; ** p<0.05; *** p<0.01. The non-linear regression is the fit with a modified Levenberg-Marquardt-type algorithm with sampling weights. The standard errors are in parentheses. The starting values, where applicable, are:* $\{\beta = 0,\ \omega = -15,\ \theta = 15,\ \gamma = 1.4,\ \sigma_{0,\upsilon} = 0,\ \sigma_{1,\upsilon} = 0, \delta = 0\}$. *For the estimation, the income variable is in thousands of annual euros. 'Switchers' are those who had 1 or 2 periods on sick leave throughout the panel but were employed the rest of the periods. Model 1 is estimated with equation (6) with* α *set at 10. Models 2 and 3 are estimated with equation (7) with* α *set at 10. Model 4 is estimated with equation (6) with an estimated* α.

Figure 3. Spline and non-linear fit of life satisfaction and income in Europe, employed vs. sick



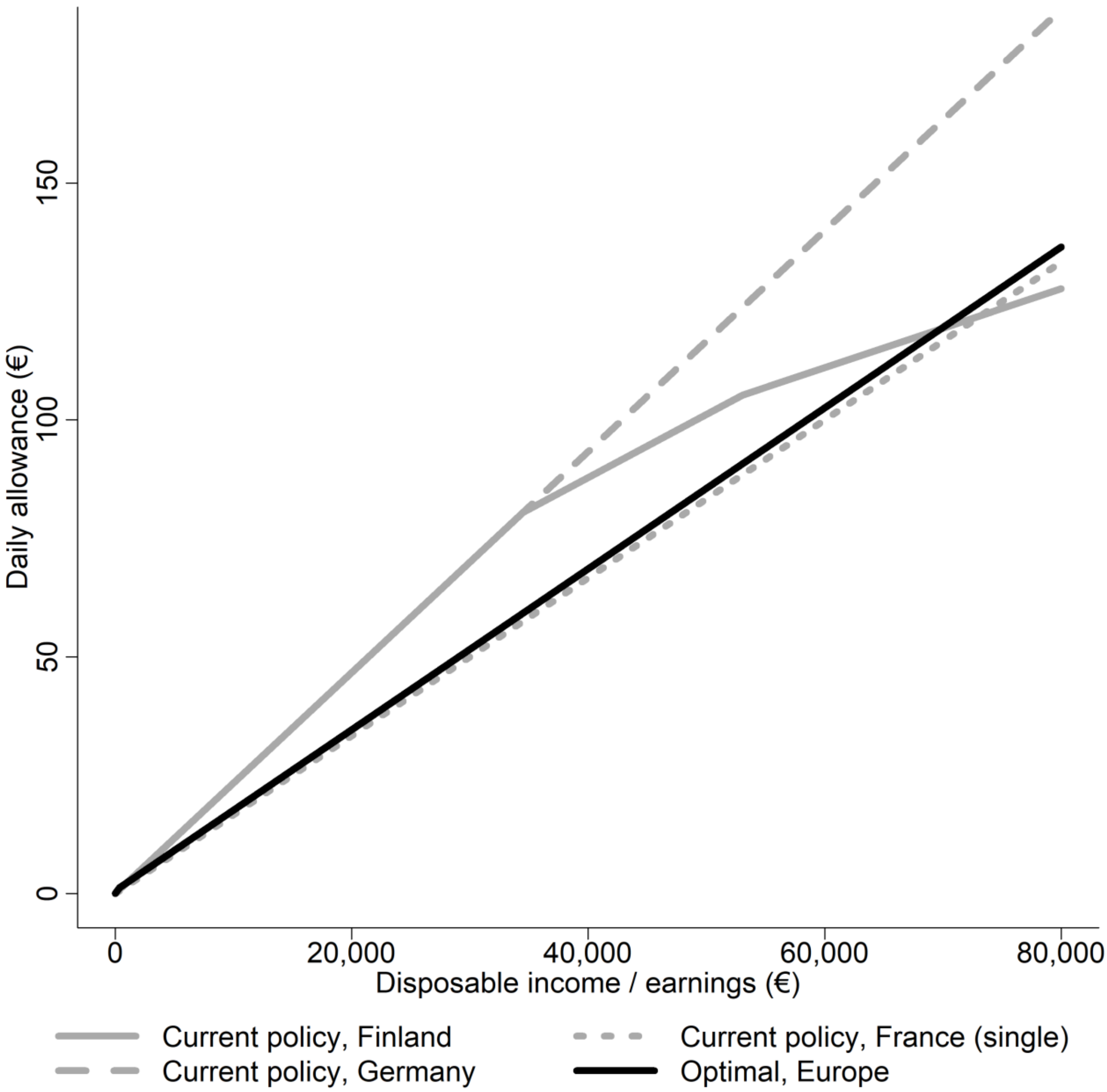
Notes. The non-parametric estimate is a spline fit. The x-axis in the figure is truncated at 80,000 euros. ***Panel A:*** *The non-linear regression fit is equation (6) with α set at 10, parameter values in Table 2, model 1, estimated using the whole income distribution. Sample size: in employment 125,166, on sick leave 1,236.* ***Panel B:*** *The non-linear regression fit is equation (6), parameter values in Table 2, model 1, estimated using the whole income distribution. The sample is the 'switcher' population. Sample size: in employment 3,390 person-year observations, on sick leave 503 person-year observations.*

Figure 4. Optimal replacement rates



Notes. The optimal replacement rates are calculated with the augmented Baily-Chetty formula (equation 1). The relative risk aversion values are from a generalized CRRA utility function with the parameter values of $\{\gamma,\ \omega,\ \theta\} = \{1.36, -18.5, 9.3\}$ *at different levels of consumption, shown in Table 2, model 2, obtained from estimating equation (7).* θ *is the fixed cost of sickness, which affects the optimal replacement rate through relative risk aversion (RRA) and the augmented Baily-Chetty formula. An assumption is that disposable income equals consumption at each period. Additionally, we assume that* $\varepsilon_{r,b} + \varepsilon_{D,b} = 1.5$. *The approximation is performed using equations (1), (3), (4) and (6).*

Figure 5. Prevailing universal sickness insurance policy and estimated optimal curves



Notes. The optimal replacement rates are calculated with the augmented Baily-Chetty formula (equation 1). The relative risk aversion values are from a generalized CRRA utility function with the parameter values of $\{\gamma,\ \omega,\ \theta\} = \{1.36, -18.5, 9.3\}$ *at different levels of consumption, shown in Table 2, model 2, obtained from estimating equation (7).* θ *is the fixed cost of sickness, which affects the optimal replacement rate through relative risk aversion (RRA) and the augmented Baily-Chetty formula. An assumption is that disposable income equals consumption in each period. Additionally, we assume that* $\varepsilon_{r,b} + \varepsilon_{D,b} = 1.5$*. "Single" refers to a one-member household. The optimal curve is based on equivalized disposable income, whereas the current policy curves are based on earnings.*

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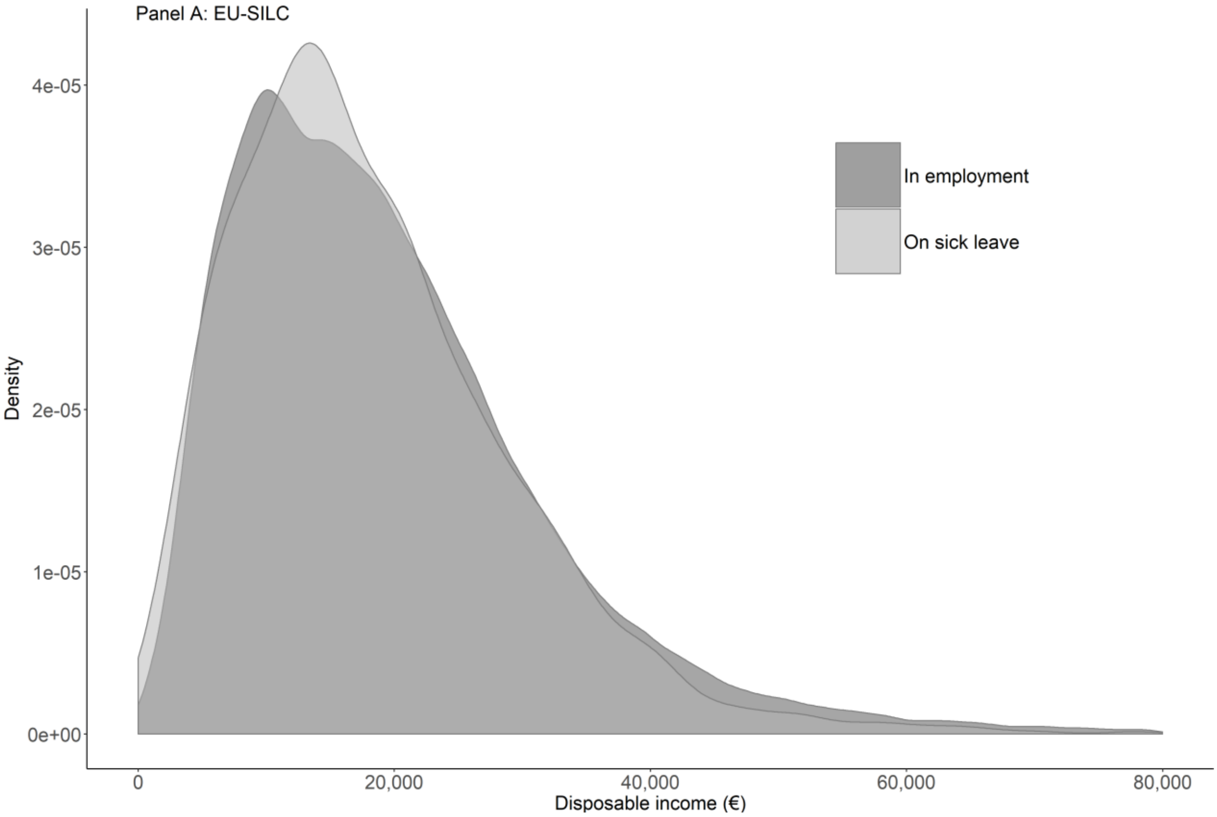
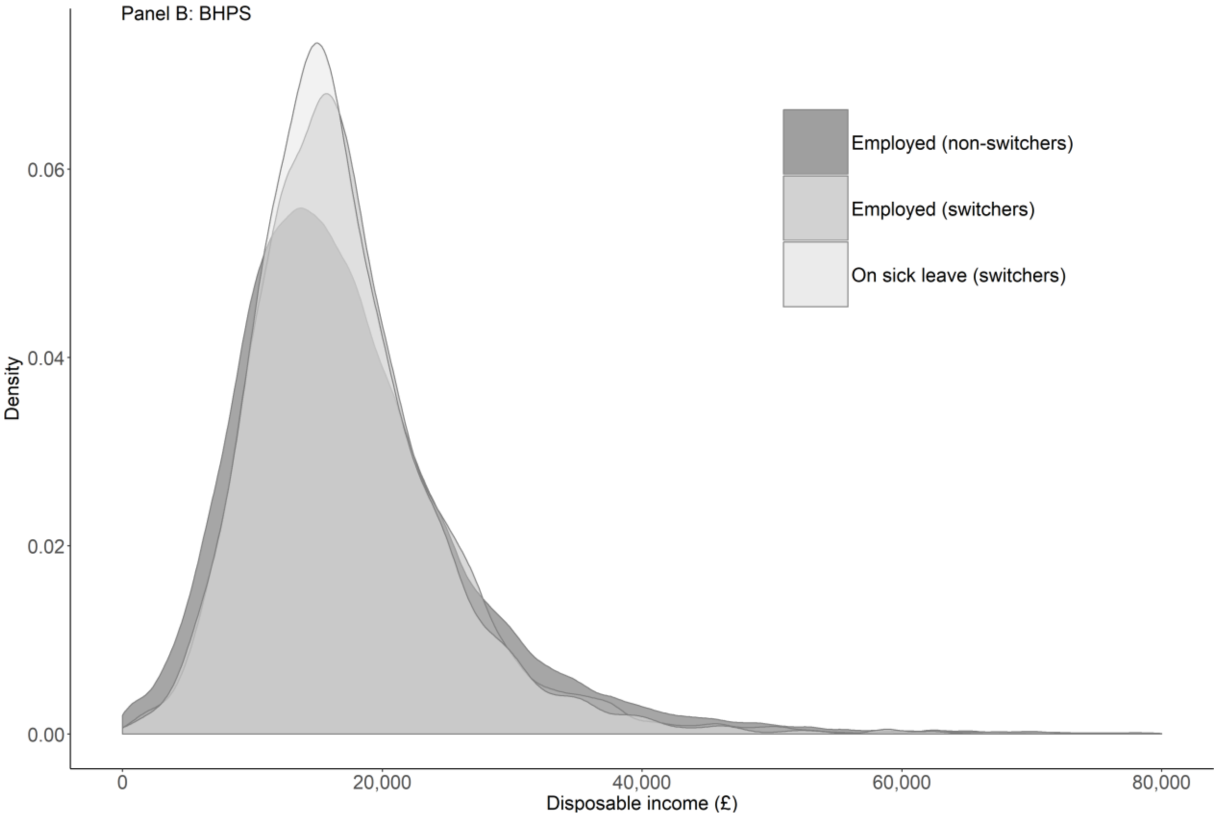
ONLINE SUPPLEMENTARY APPENDIX

Appendix 1: Additional figures and tables

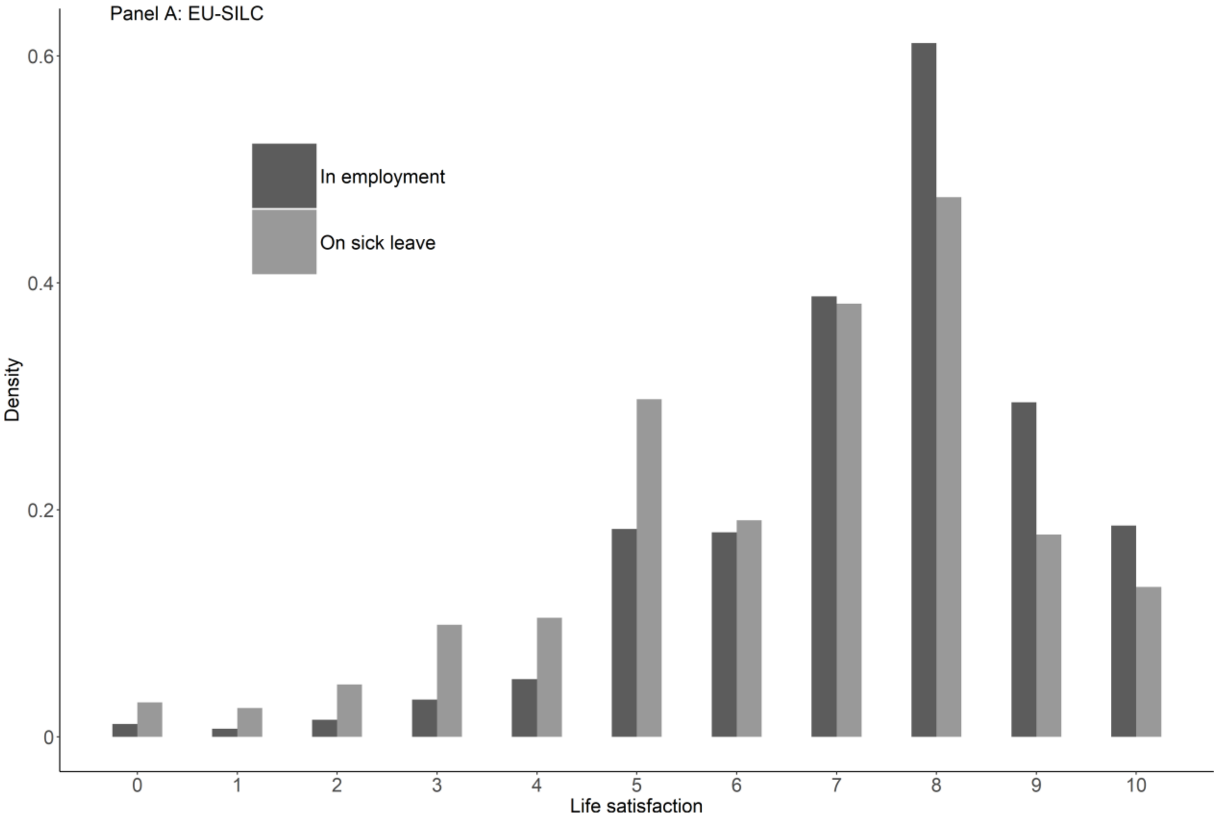
Figure A1. Histogram of incomes of the employed and sick leave samples

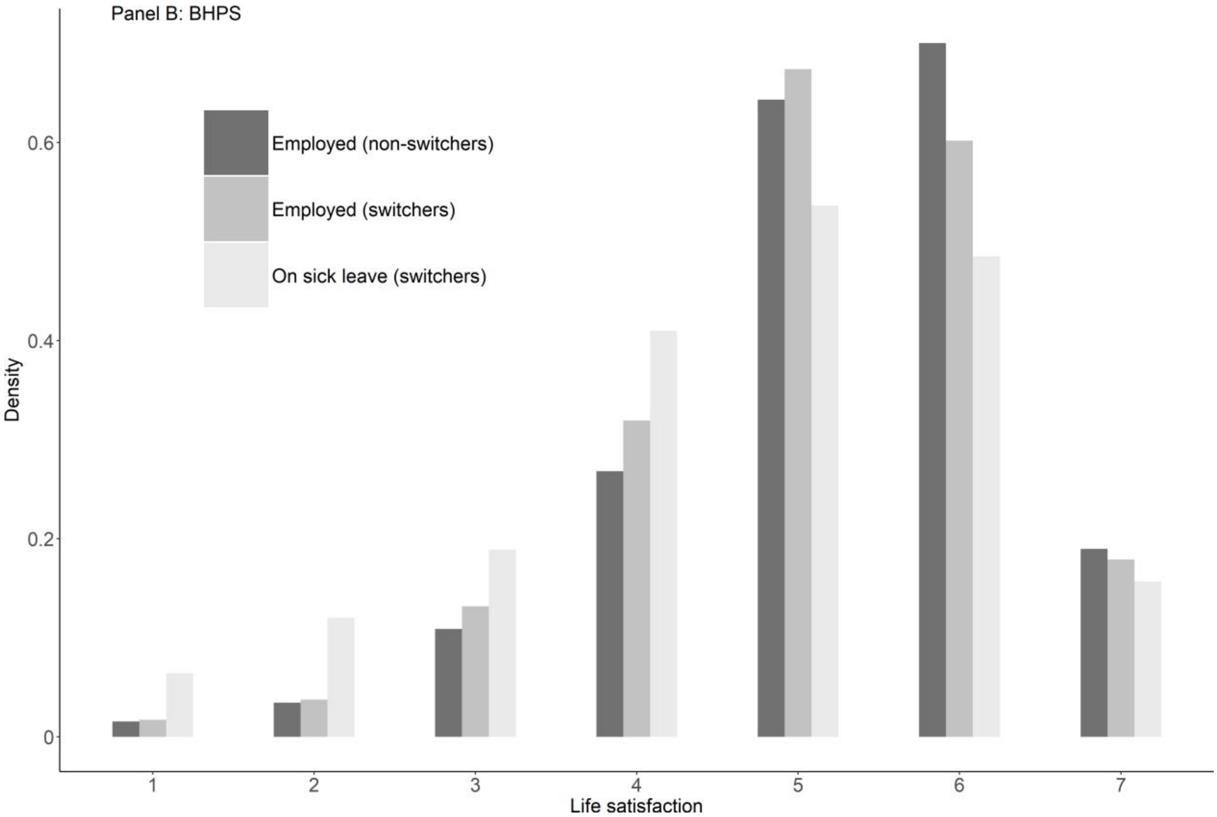




Notes. ***Panel A.*** *Sample size: in employment 125,166, on sick leave 1,236.* ***Panel B.*** *Sample size (person-year observations): 83,771 'non-switchers' in employment, 6,326 'switchers' in employment and 1,225 'switchers' on sick leave.*

Figure A2. Histogram of life satisfaction of the employed and sick leave samples



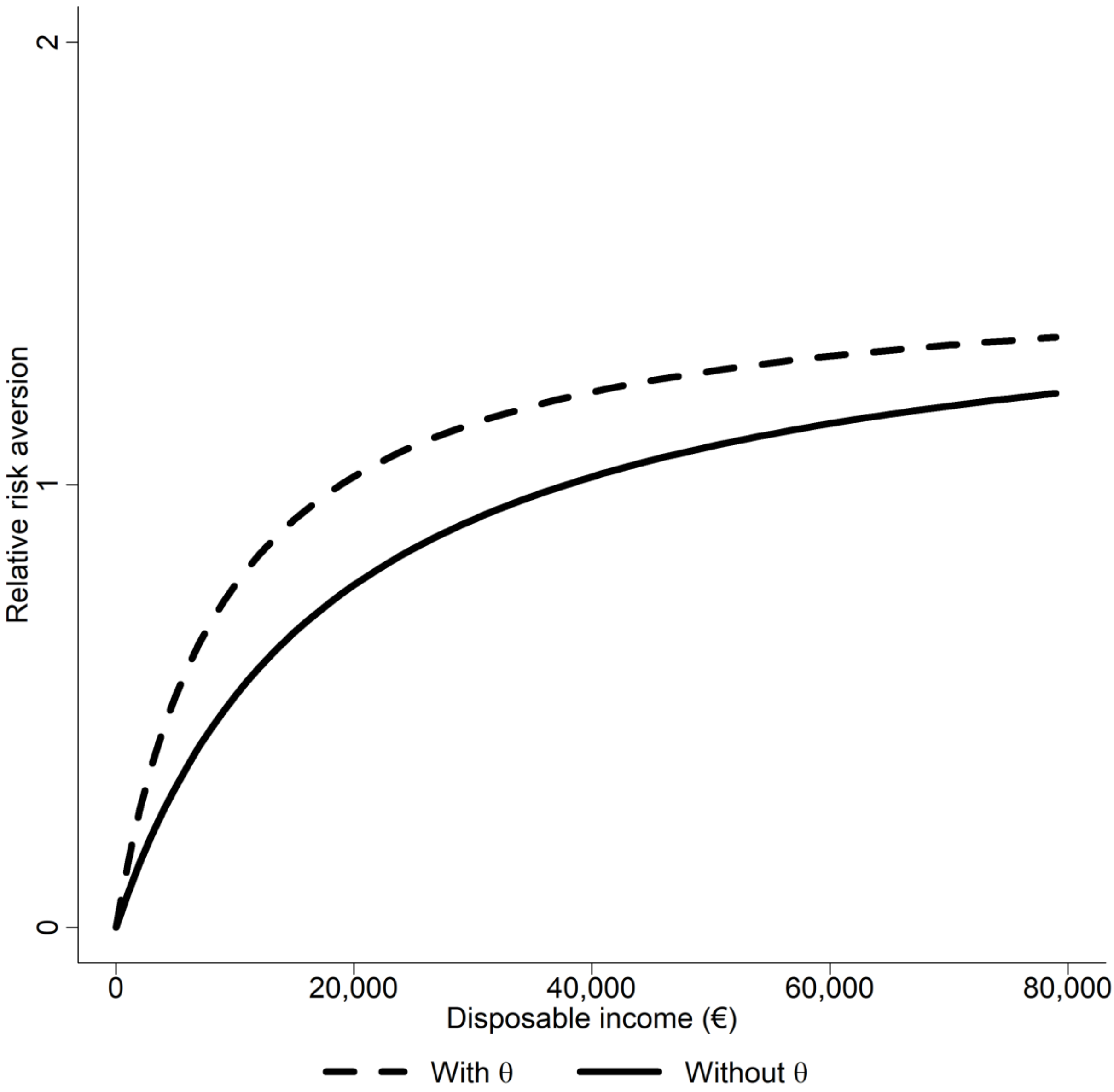


Notes. ***Panel A.*** *Sample size: in employment 125,166, on sick leave 1,236.* ***Panel B.*** *Sample size (person-year observations): 83,771 'non-switchers' in employment, 6,326 'switchers' in employment and 1,225 'switchers' on sick leave.*

Figure A3. Theoretical patterns of marginal utilities

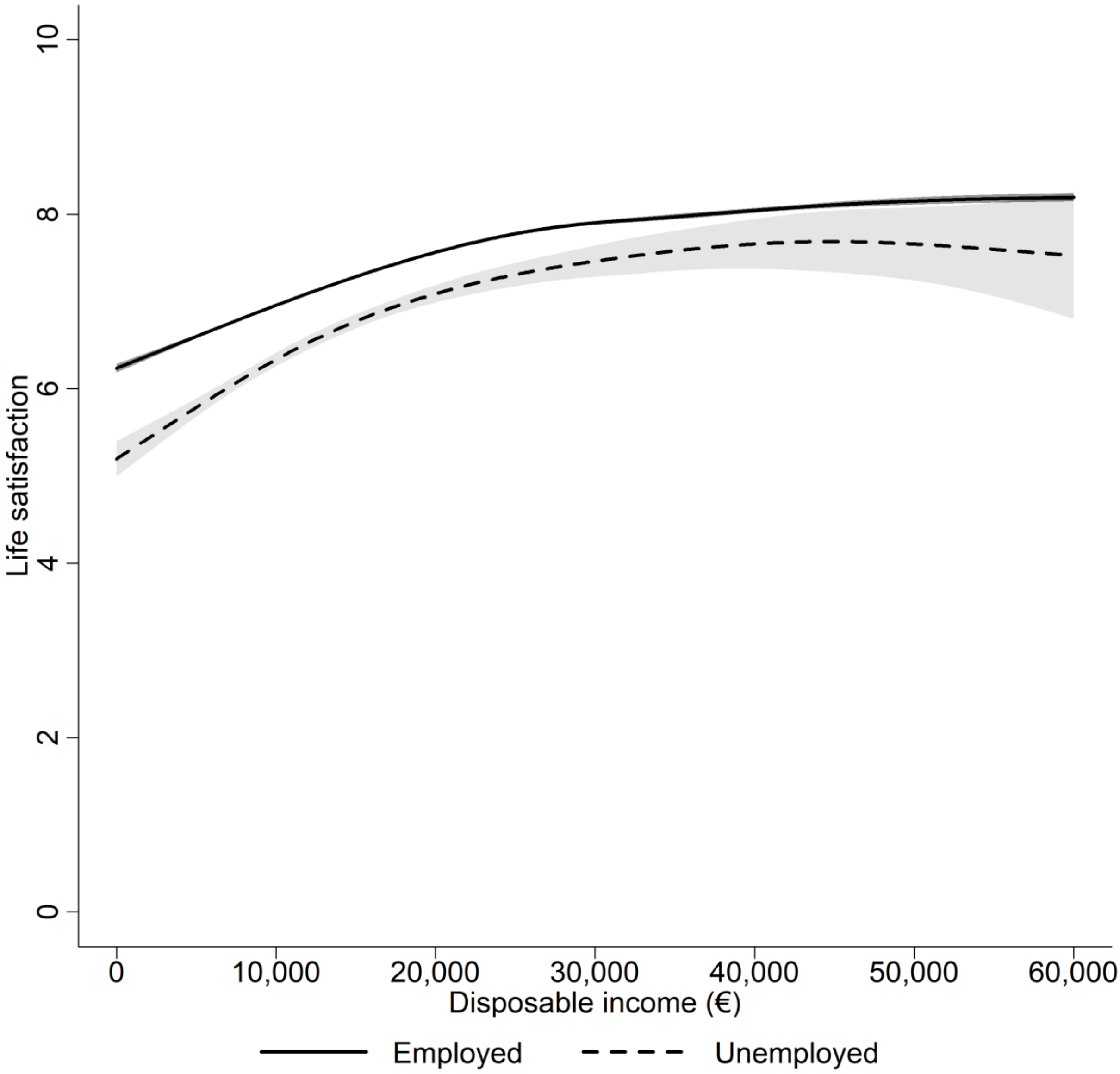
Notes. Adapted from Finkelstein et al. *(2013).* ***Panel A.*** *The panel presents a utility function with positive state-dependence*, i.e., *a utility function with higher marginal utility at each consumption level when on sick leave.* ***Panel B.*** *The panel presents a utility function with negative state-dependence,* i.e., *a utility function with lower marginal utility at each consumption level when on sick leave.*

Figure A4. Estimated relative risk aversion



Notes. The relative risk aversion values are from a generalized CRRA utility function with parameter values of $\{\gamma,\ \omega,\ \theta\} = \{1.36, -18.5, 9.3\}$ *at different levels of consumption, shown in Table 2, model 2, obtained from estimating equation (7). An assumption is that disposable income equals consumption in each period.*

Figure A5. Spline of life satisfaction and income in Europe, employed vs. unemployed



*Notes. The estimate is a cubic spline with six knots estimated with the R package "bigsplines" with default parameter values. The gray area around the curves represents the 95% confidence interval. Sample size: 130,941 in employment, 4,625 in unemployment. The constant (α) is assumed to be 10. A fit similar to Figure 3 yields the following parameter values: the scale parameter (β) is 7.41*** (1.83), the relative risk aversion parameter (γ) is 1.48*** (0.04), the institutions parameter (ω) is -22.08*** (2.95), the fixed cost of unemployment (θ) is 11.42*** (1.28) and the level effect of unemployment (δ) is -0.05 (0.08).*

Appendix 2: Augmented Baily-Chetty model

We adapt the canonical Baily-Chetty model of unemployment insurance to sickness insurance (Baily, 1978; Chetty, 2006; Chetty and Finkelstein, 2013). Consider a representative worker who has an initial level of assets A_0 and wage w. Assume that the agent is injured or becomes ill at work with probability $p(E)$, usually denoted p. $p(E)$ is a decreasing function of E, his chosen sickness-avoidance effort level, with convex effort cost $\psi_E(E)$. If the agent is injured or becomes ill, he takes sick leave. In the sick state, there is no risk of repeated sickness or unemployment, and the agent makes no labor supply choices. In the sick state, the agent must be rehabilitated to return to work.

In the sick state, the agent receives a benefit, b, for the duration of the sickness benefit and subsequently returns to work. The sickness duration, D, is assumed to be a choice variable. Non-pecuniary costs and benefits of sickness duration and effort are captured by concave increasing functions $\psi_D(D)$ and $\psi_E(E)$. Let $k \in \{e, s\}$ and $U_k(c_k)$ be strictly concave utility over consumption, where subscripts *e* and *s* stand for being at work and on sick leave, respectively. The utility is assumed to be state-dependent, specifically with a fixed cost of sickness, $u(c, 1) = u(c - \theta)$, $\theta > 0$. The agent chooses c_e, c_s, *E* and *D* at time 0 to solve,

$$max\ (1 - p(E))u(c_e, 0) + p(E)\big(u(c_s, 1) + \psi_D(D)\big) - \psi_E(E)$$

$$s.t.\, A_0 + (w - \tau) - c_e \geq 0$$

$$A_0 + bD + w(1 - D) - c_s \geq 0.$$

while taking $(b,\ \tau)$ as fixed. This assumption is critical. The social planner chooses the benefits, *b*, that maximize the agent's indirect utility under the condition that taxes collected (τ) equal benefits paid. The taxes here are modeled to be lump sum, so they do not affect labor supply choices under no sickness.[7] The social planner's problem, with p*(E)*, written as *p*, is as follows:

$$\max_{\tau,b,E} V(b,\tau,E)$$

$$s.t. (1-p)\tau \geq pbD.$$

At the optimum, the optimal benefit rate, $b*$, must satisfy the following:

$$\frac{dV(b,\tau,E)}{d(b^*)} = 0,$$

where τ and E are functions of b.

$$V(b) = \max_{c_e,c_s,D,E,\lambda_e,\lambda_s} (1-p)u(c_e,0) + p\big(u(c_s,1) + \psi_D(D)\big) - \psi_E(E) + \lambda_e[A_0 + w - \tau - c_e]$$
$$+ \lambda_u[A_0 + bD + (w-\tau)(1-D) - c_s].$$

The function is optimized over $\{c_e, c_s, D, E, \lambda_e, \lambda_s\}$. We assume that the value function $V(b)$ is differentiable such that the envelope theorem applies. Thus, following the envelope theorem, changes in the functions have no first-order effect. Specifically, $\frac{dE}{db} = 0$, giving the interior optimum as follows:

$$\frac{dV(b,\tau,E)}{Db(b^*)} = -\lambda_e \frac{d\tau}{db} + \lambda_s D = 0. \qquad \text{(A1)}$$

From the agent optimization, we know that

$$\lambda_e = (1-p)u(c_e,0) \text{ and } \lambda_s = pu(c_s,1). \qquad \text{(A2)}$$

From the social planner budget constraint, on which the change in effort does have a first-order effect:

[7] If modeled, they would add a component on the cost side.

$$\frac{d\tau}{db} = \frac{\mathrm{p}}{1-\mathrm{p}}\left(\mathrm{D} + \frac{\mathrm{bdD}}{\mathrm{db}}\right) + \frac{\mathrm{Db}}{(1-p)}\frac{\mathrm{d}\log(\frac{p}{1-p})}{\mathrm{db}} \tag{A3}$$

Substituting (A3) and (A2) into (A1) yields an implicit equation for the optimal policy (an augmented Baily-Chetty formula):

$$\varepsilon_{D,b} + \varepsilon_{r,b} = \frac{u'(c_s,1) - u'(c_e,0)}{u'(c_e,0)} = \frac{u'(c_s-\theta,1) - u'(c_e,0)}{u'(c_e,0)} \approx \gamma\frac{\Delta c+\theta}{c_e}\left[1 + \frac{1}{2}\rho\frac{\Delta c+\theta}{c_e}\right], \tag{A4}$$

where $\frac{\Delta c}{c_e}$ is the proportional drop in consumption while on sick leave; $\gamma = -\frac{C_e u''(C_e,0)}{u'(C_e,0)}$ is the coefficient of relative risk aversion; $\rho = -\frac{C_e u'''(C_e,0)}{u''(C_e,0)}$ is the coefficient of relative prudence; $\varepsilon_{r,b} = \frac{d\log(\frac{p}{1-p})}{d\log(b)}$ is the elasticity of the odds ratio ($r = \frac{p}{1-p}$) of sickness leave with respect to the sickness benefit, i.e., the extensive margin; and $\varepsilon_{D,b} = \frac{d\log(D)}{d\log(b)}$ is the elasticity of the duration of sick leave with respect to the sickness benefit, i.e., the intensive margin. The right-hand side of the formula approximates the increase in relative marginal utility given the drop in consumption under sick leave and yields an implicit equation for the optimal benefit, *b*, which is based on the sufficient statistics approach, $\left(\varepsilon_b, \frac{\Delta c+\theta}{c_e}, \gamma\right), \varepsilon_b = \varepsilon_{D,b} + \varepsilon_{r,b}$.

The welfare change can be written in terms of relative marginal utilities of consumption in the two states. If individuals' behaviors were not distorted by the provision of insurance, the social planner would achieve the first best by setting b to perfectly smooth utilities, $u'_s(c_s, 1) = u'_e(c_e, 0)$. Note that equation (A4) is an implicit one. However, the envelope theorem guarantees that one need not fully characterize all of the margins to which individuals can respond to calculate the net welfare gain of social insurance. In particular, all other behavioral responses can be ignored when setting the optimal benefit level except for the elasticity parameters ($\varepsilon_{D,b}$ and $\varepsilon_{r,b}$) that enter the government budget constraint directly.

However, the social planner cannot directly choose observed consumption levels or Δc (hidden savings); rather, it determines the benefit level, which influences income replacement rates, which are observable. Kolsrud et al. (2018) find that the consumption drop increases with the duration of an unemployment spell and that savings and credit play a limited role in smoothing consumption. Equating consumption with income, we can directly solve for the optimal $\frac{\Delta y}{y_e}$ using equation (2):

$$RR = 1 - \frac{\Delta \mathrm{y}}{y_e} = \left(\frac{\omega}{y_e} + \frac{\theta}{y_e}\right) + \left(1 - \frac{\omega}{y_e}\right)\left(1 + \varepsilon_{r,b} + \varepsilon_{D,b}\right)^{-\frac{1}{\gamma}}, \tag{A5}$$

We employ the form $u(y, S) = u(c(y) - \theta S)$ as a simple parametrization of the state-dependent utility of the qualitative type we have observed in Figure 1. The social planner now must consider θ in addition to the standard Baily-Chetty parameters $\{\varepsilon_b, \gamma, \rho\}$ for optimal policy. The relationship observed by Finkelstein et al. (2013) would require an alternative functional form.

The envelope theorem plays a critical role in generalizing (A4) with minor modifications to more realistic dynamic models with endogenous savings and borrowing constraints (Chetty and Finkelstein, 2013). One could also complement the model following Kolsrud et al. (2018), who model the effect of duration-dependent benefit rates in unemployment.

In the standard Baily-Chetty formula, it is possible that a non-linear benefit rule is optimal if risk aversion or the incentive effect varies significantly according to the income level. Additionally, if the aim of the insurance scheme is to contribute to the redistribution of income from rich to poor households, a non-linear benefit rule might be motivated well.

Appendix 3: Sickness insurance in Europe

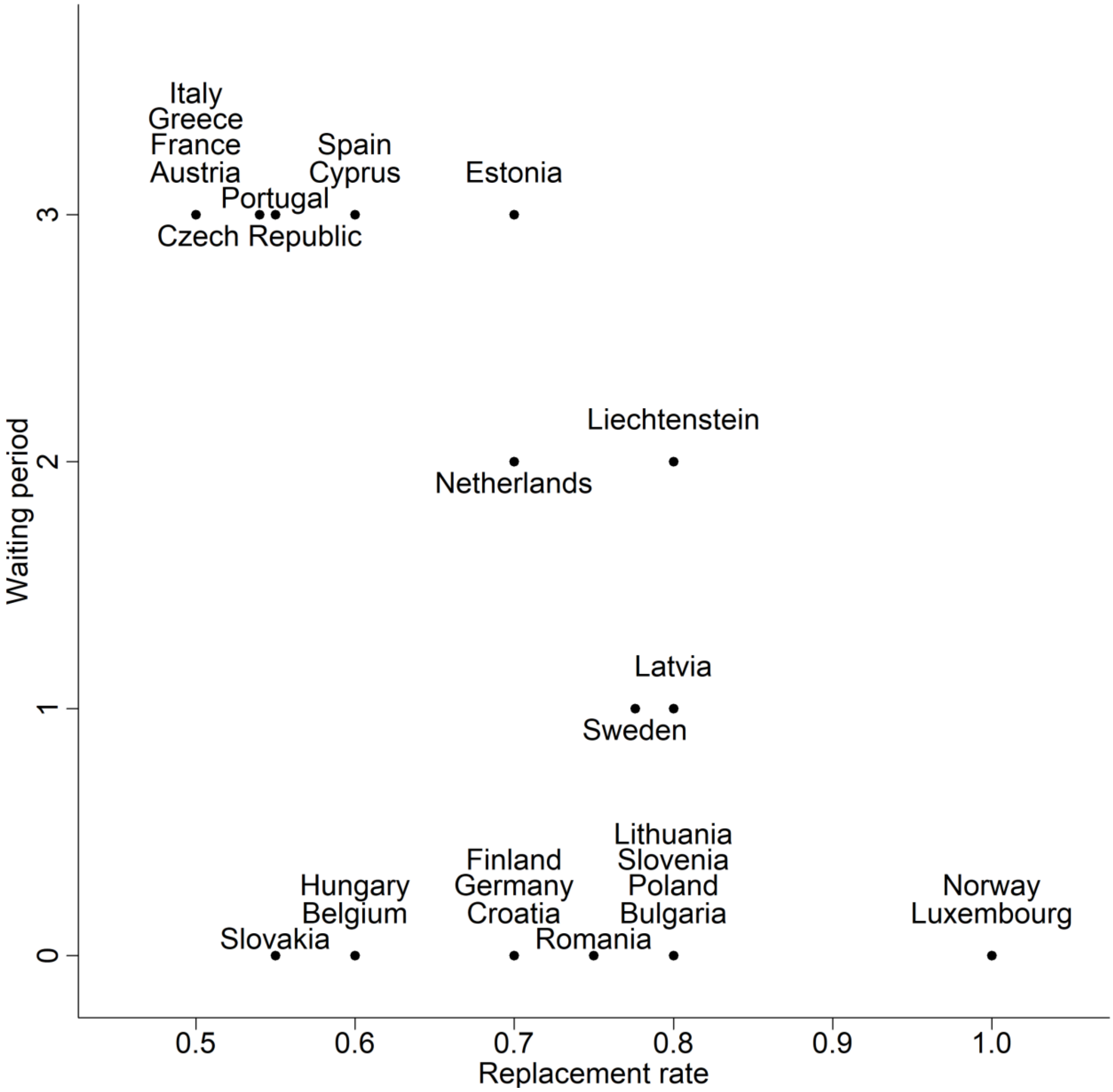
MISSOC (2017) comparative tables describe the European sickness insurance schemes (cf. Frick and Malo, 2008). The tables distinguish at least five dimensions, in which the schemes differ. Two of the key dimensions are depicted in Figure A3. The crucial aspect in any social insurance system is the replacement rate, i.e., the rate at which pre-sickness income is covered by sickness insurance. The replacement rates vary in Europe from 50% (Italy, Greece, France and Austria) to 100% (Luxembourg and Norway). However, some European countries (Iceland, Ireland, Malta and the UK) have a lump-sum benefit. Lump-sum benefits imply highly regressive replacement rates and are therefore not shown in Figure A2.1.

The other important dimension presented in Figure A2.1 is the waiting period. A waiting period is the amount of time the person must pass on sick leave before being eligible for the benefit. The waiting periods vary between 0 and 3 days in the countries with proportional replacement rates. Three-day waiting periods are found in Southern Europe, the Czech Republic and Estonia. Northern European countries tend to have no waiting periods at all. The waiting period plays a large role in short sickness spells.

The other three dimensions in which European sickness insurance schemes differ are coverage, maximum duration and qualifying period. Coverage is broad for full-time employees in all countries in Europe and varies primarily in terms of how the self-employed are treated. Maximum durations vary slightly between countries such that the mode is at one year. The qualifying periods, that is, the time required at the job before eligibility, vary from none to 6 months.

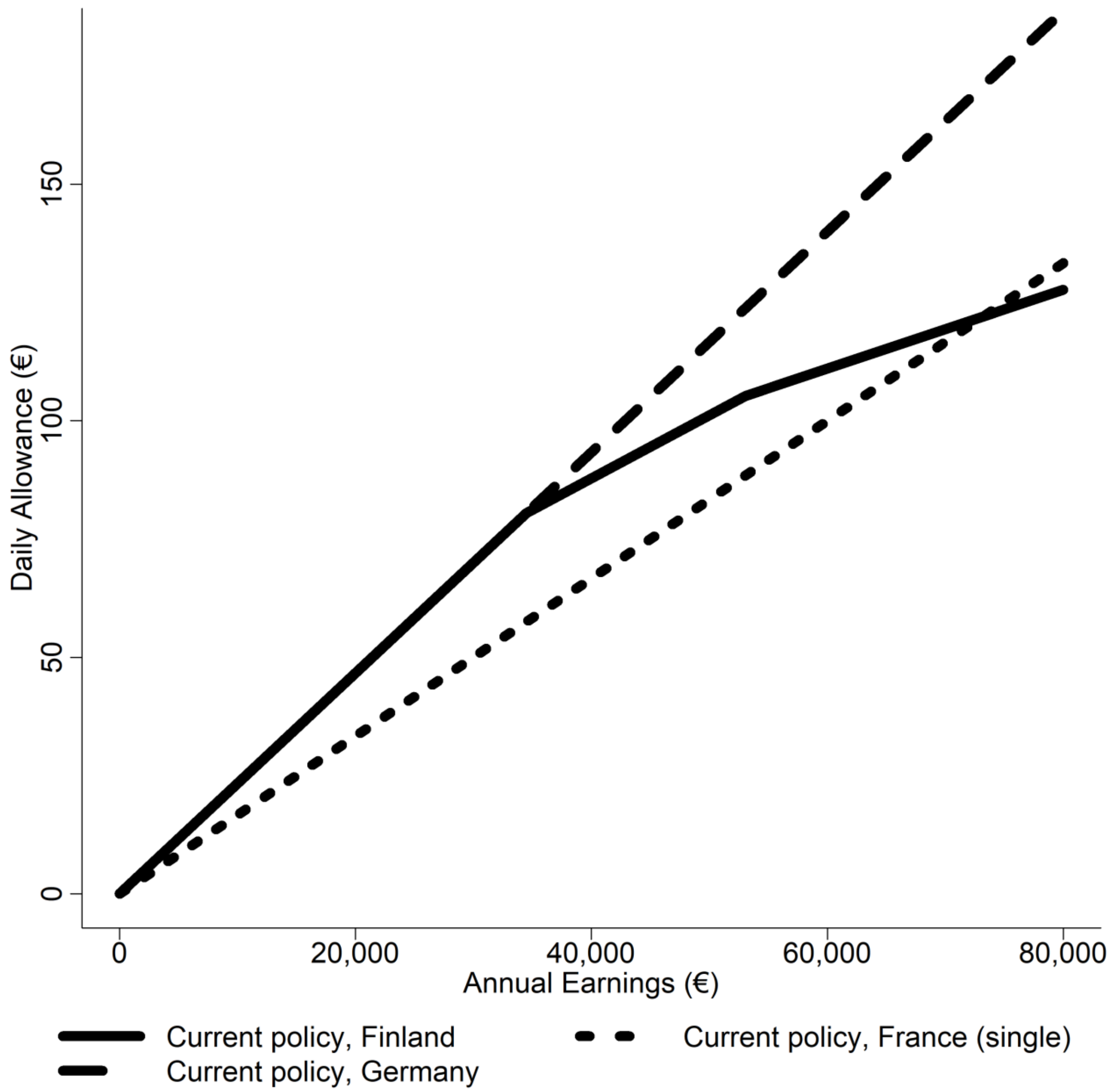
To capture within-country heterogeneity in the replacement rates, Figure A2.1 is insufficient. Some countries, such as Finland, have notably non-linear benefit rules. The benefit curves for Germany, France and Finland are depicted in Figure A2.2.

Figure A2.1. Characteristics of sickness insurance schemes in Europe



Notes. Single, lowest income bracket, initial benefit level, and the general case for long-term employment. Denmark: not defined in the table. Iceland, Ireland, Malta and the UK: lump sum benefit. Switzerland: varies by individual contract. Source: MISSOC comparative table, 2017/07/01.

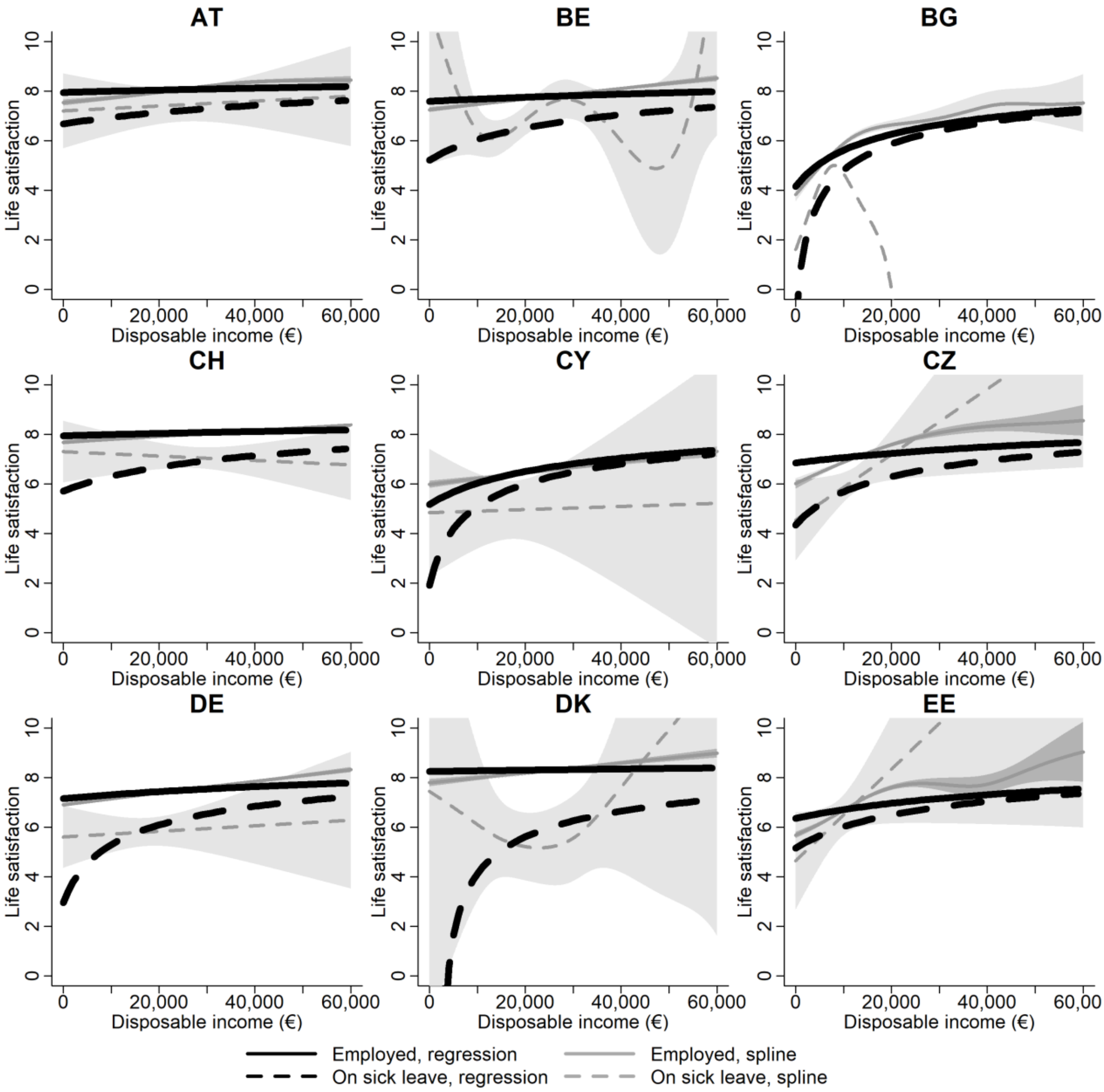
Figure A2.2. Generosity of sickness insurance schemes in three European countries



Appendix 4. Country-specific estimates of ω (i.e., the value of institutions)

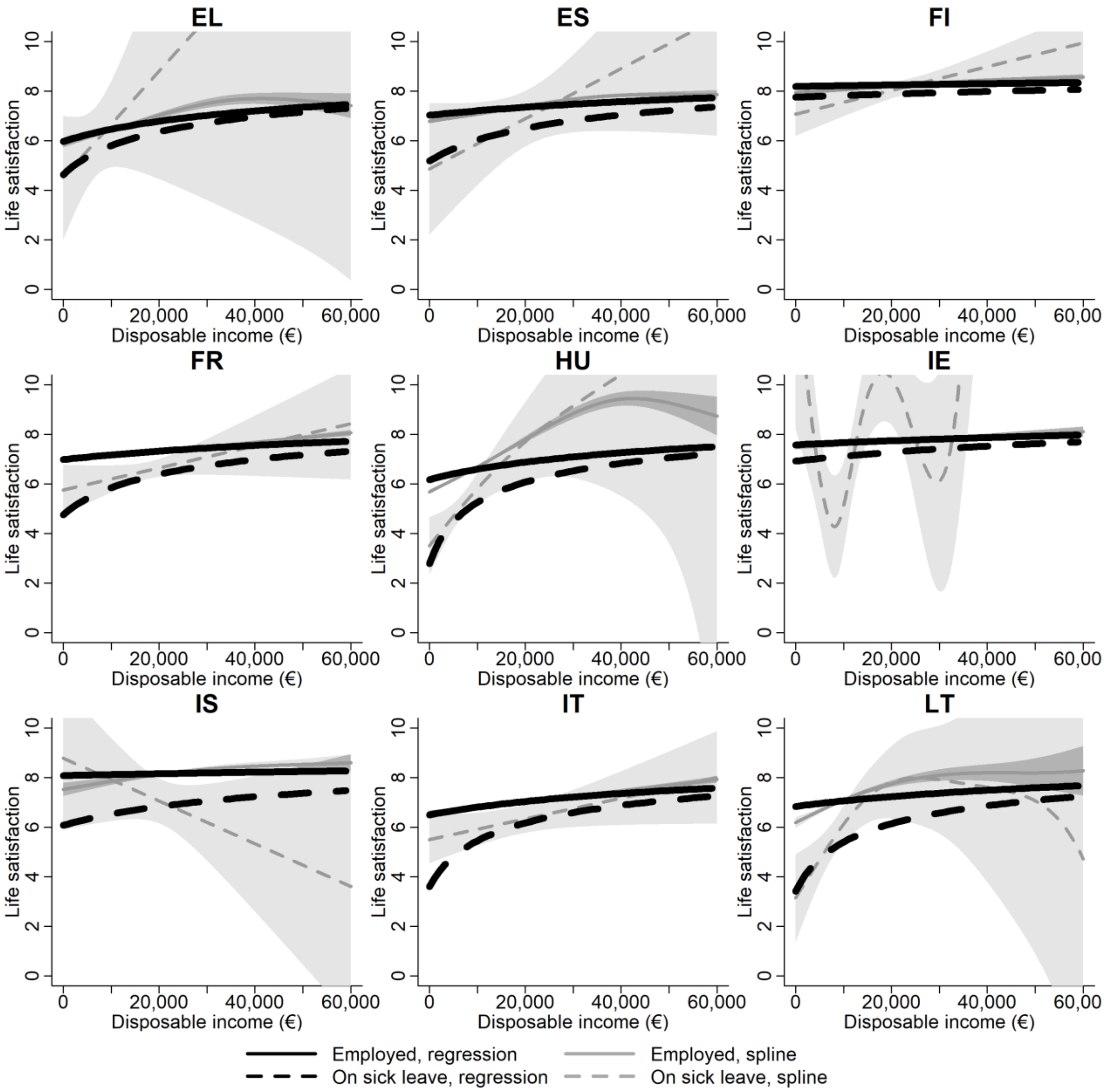
Figure A4.1 presents country-level profiles for the relationship between disposable income and life satisfaction as a spline fit. The figures also show the fit of equation (7), where only ω and θ are allowed to vary and all other parameters are held constant at values presented in Table 2, column 2. Table A4.1. shows the sample size by each country. Figure A4.2 shows the values of ω at the country level plotted against covariates.

Figure A4.1. Spline and non-linear regression fit of life satisfaction and income by country, employed vs. sick



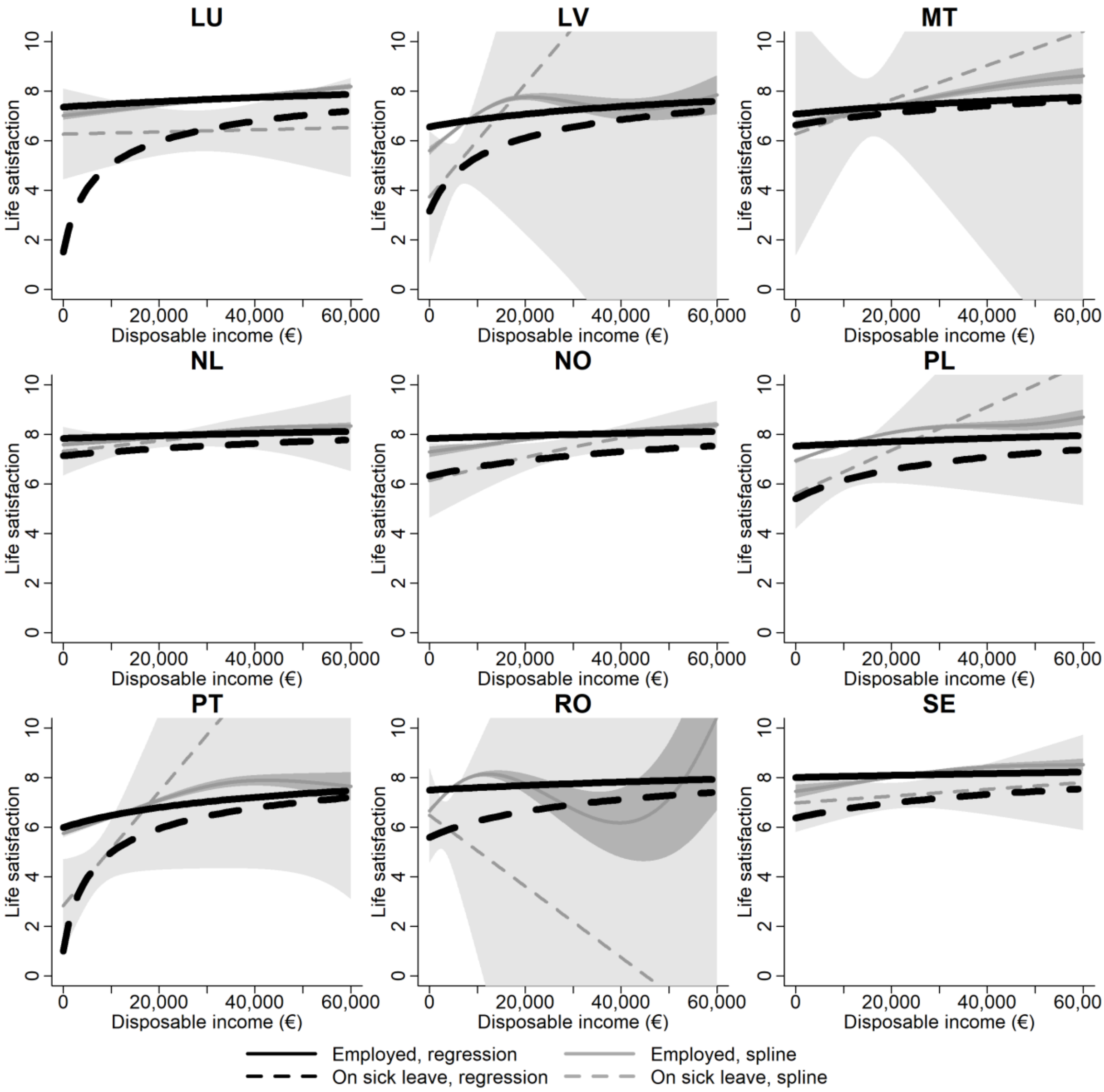
Notes. The estimate is a spline fit. The fit is performed using the whole income distribution, although the x-axis in the figure is truncated at 60,000 euros. Country codes: AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czech Republic, DE=Germany, DK=Denmark, EE=Estonia.

Figure A4.1 (cont.). Spline and non-linear regression fit of life satisfaction and income by country, employed vs. sick



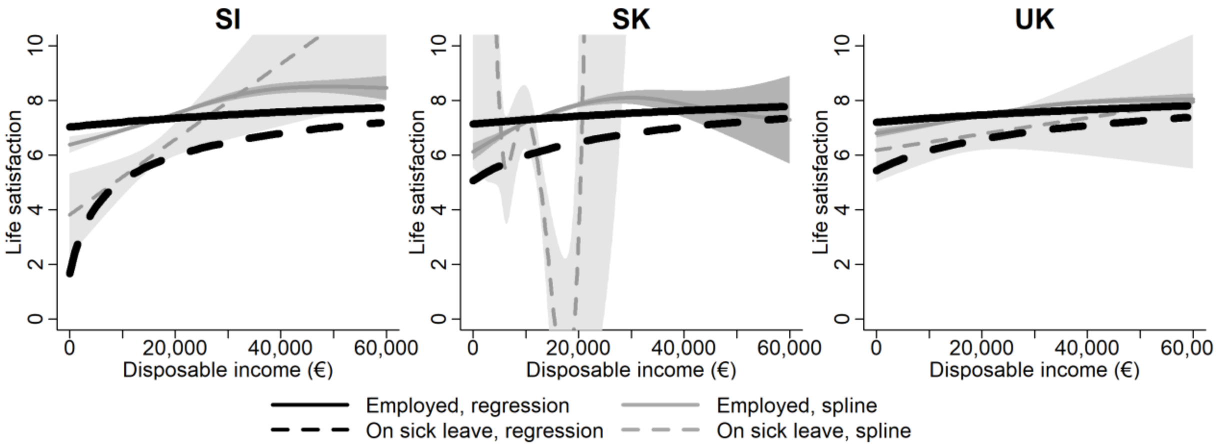
Notes. The estimate is a spline fit. The fit is performed using the whole income distribution, although the x-axis in the figure is truncated at 60,000 euros. Country codes: EL=Greece, ES=Spain, FI=Finland, FR=France, HU=Hungary, IE=Ireland, IS=Iceland, IT=Italy, LT=Lithuania.

Figure A4.1 (cont.). Spline and non-linear regression fit of life satisfaction and income by country, employed vs. sick



Notes. The estimate is a spline fit. The fit is performed using the whole income distribution, although the x-axis in the figure is truncated at 60,000 euros. Country codes: LU=Luxembourg, LV=Latvia, MT=Malta, NL=Netherlands, NO=Norway, PL=Poland, PT=Portugal, RO=Romania, SE=Sweden.

Figure A4.1 (cont.). Spline and non-linear regression fit of life satisfaction and income by country, employed vs. sick

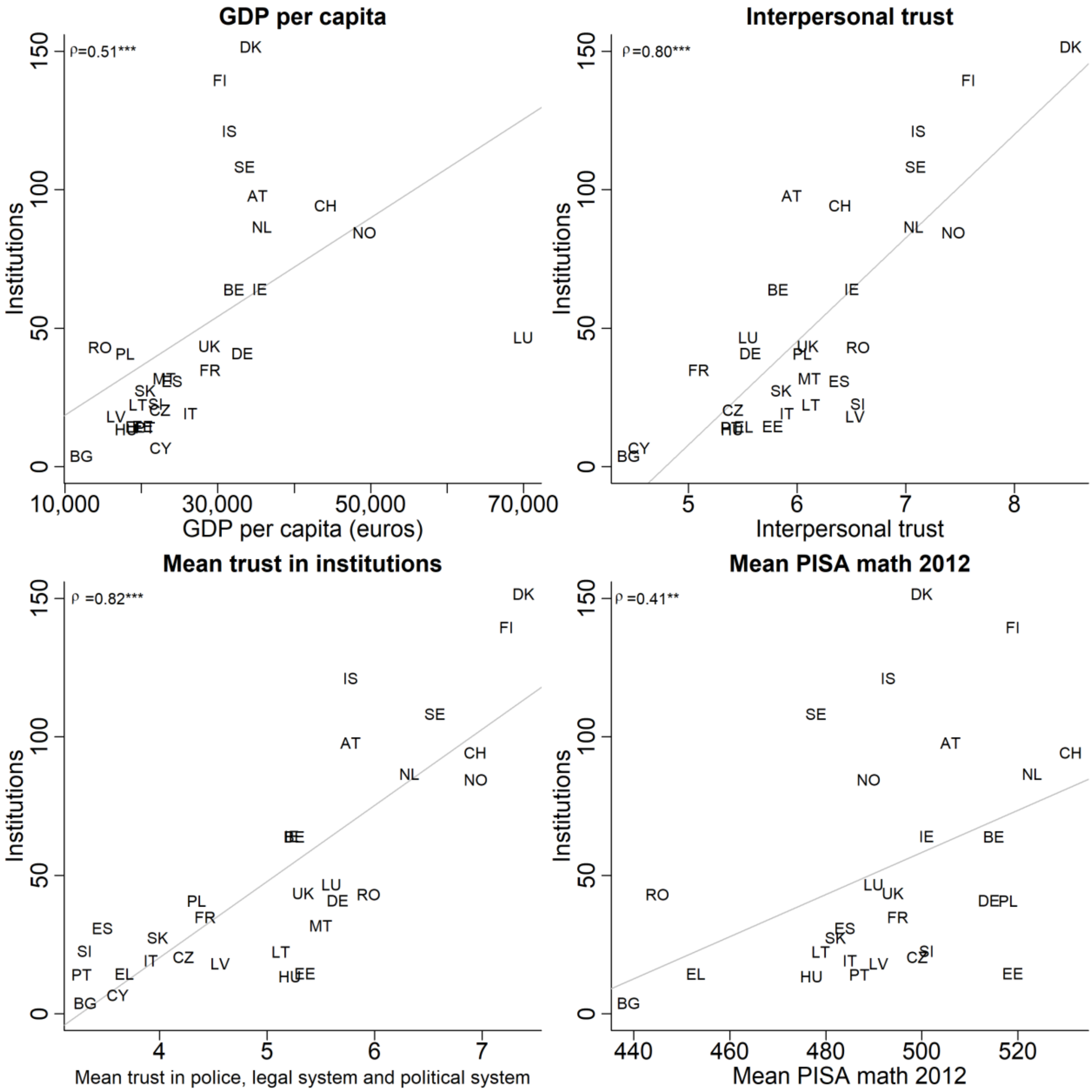


Notes. The estimate is a spline fit. The fit is performed using the whole income distribution, although the x-axis in the figure is truncated at 60,000 euros. Country codes: SI=Slovenia, SK=Slovakia, UK=United Kingdom.

Table A4.1. Sample size by country and subset

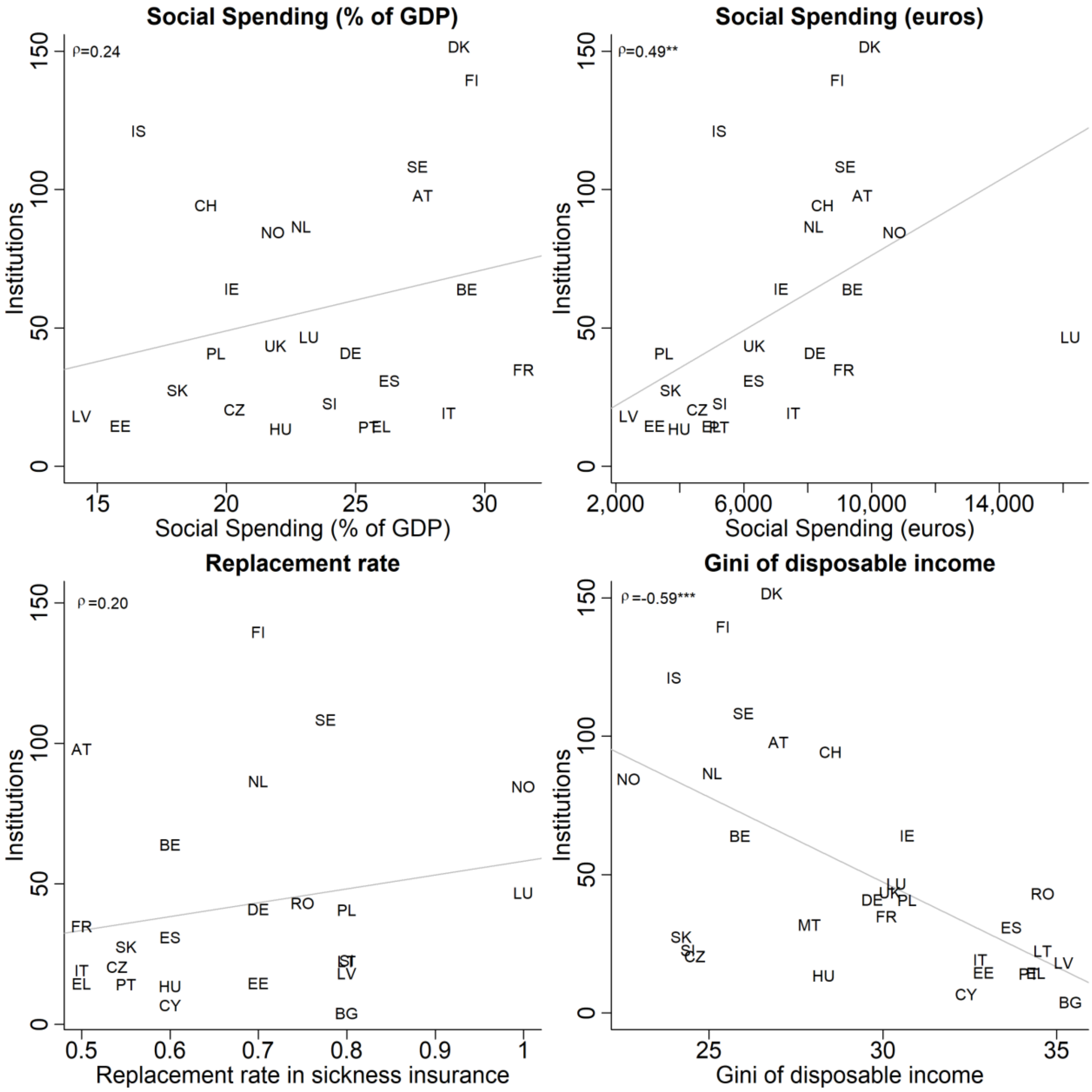
	Employed	On sick leave
Austria	3,805	36
Belgium	3,521	39
Bulgaria	2,757	3
Switzerland	5,143	95
Cyprus	3,944	18
Czech Republic	4,357	45
Germany	6,857	55
Denmark	2,428	14
Estonia	4,077	33
Greece	3,782	16
Spain	7,757	17
Finland	4,782	40
France	5,605	89
Hungary	6,416	94
Ireland	1,637	11
Iceland	1,429	15
Italy	7,984	39
Lithuania	2,839	38
Luxembourg	1,946	31
Latvia	3,257	16
Malta	2,179	6
The Netherlands	3,740	99
Norway	3,046	98
Poland	7,609	31
Portugal	3,649	21
Romania	4,767	14
Sweden	2,606	55
Slovenia	3,722	81
Slovakia	4,729	16
United Kingdom	4,796	71

Figure A4.2. Country-level scatter plots



*Notes. Statistical significance of correlation: * p<0.1; ** p<0.05; *** p<0.01. All figures show a scatter plot and correlations for 30 countries except the top left panel, which is for 25 countries, and the bottom right panel, which is for 28 countries. Source. Income: Eurostat ppp GDP per capita. PISA math: PISA. All other sources: own calculations using EU-SILC.*

Figure A4.2 (cont.). Country-level scatter plots



*Notes. Statistical significance of correlation: * p<0.1; ** p<0.05; *** p<0.01. All figures show a scatter plot and correlations for 25 countries in the top panels and 24 and 30 countries in the bottom left and right panels, respectively. Source. Social spending: OECD, GDP and Gini: Eurostat. Replacement rate: MISSOC (2017). All other sources: own calculations using EU-SILC.*

Table A4.2. Estimated relative contribution of the institutions parameter (ω) and consumption at mean income by country

Country	Mean life satisfaction (EU-SILC)	Estimated utility at mean GDP	Estimated utility at zero income	Contribution of consumption to utility	Relative contribution of institutions to utility (%)
Austria	8.1	7.9	7.6	0.2	96.8
Belgium	7.8	7.6	7.2	0.4	95.0
Bulgaria	5.5	5.4	2.5	3.0	45.1
Switzerland	8.1	7.9	7.6	0.3	96.0
Cyprus	6.5	6.3	3.8	2.5	59.8
Czech Republic	7.2	6.8	5.8	1.0	85.6
Germany	7.5	7.4	6.7	0.6	91.4
Denmark	8.3	8.1	8.0	0.1	98.2
Estonia	6.8	6.5	5.3	1.3	80.6
Greece	6.6	6.5	5.2	1.2	80.8
Spain	7.4	7.1	6.4	0.7	90.4
Finland	8.3	8.0	7.9	0.1	98.2
France	7.4	7.2	6.5	0.7	90.6
Hungary	6.6	6.4	5.1	1.3	80.1
Ireland	7.8	7.6	7.2	0.4	94.6
Iceland	8.2	8.0	7.8	0.2	97.8
Italy	7.1	6.9	5.7	1.1	83.3
Lithuania	7.1	6.8	5.9	0.8	87.9
Luxembourg	7.7	7.8	6.9	0.9	88.7
Latvia	6.9	6.5	5.6	0.9	86.0
Malta	7.4	7.1	6.4	0.6	91.0
Netherlands	8.0	7.8	7.5	0.3	96.2
Norway	8.0	7.9	7.5	0.4	95.1
Poland	7.6	7.1	6.7	0.4	94.4
Portugal	6.6	6.5	5.2	1.3	79.9
Romania	7.6	7.1	6.8	0.3	95.5
Sweden	8.1	7.9	7.7	0.2	97.3
Slovenia	7.3	6.8	6.0	0.9	87.2
Slovakia	7.3	6.9	6.2	0.7	90.1
United Kingdom	7.5	7.3	6.8	0.5	92.7

Notes. The values presented in columns 3–6 are based on a fit of equation (7), in which only ω and θ are allowed to vary and all other parameters are held constant at values presented in Table 2, column 2.