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The subjective costs of health losses due to chronic diseases. An alternative model for monetary appraisal

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An alternative model for monetary appraisal †

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Abstract

This paper proposes a method to evaluate health losses or gains by looking at the impact on well-being of a change in health status. The paper presents estimates of the equivalent income change that would be necessary to change general satisfaction with life to the same extent as a change in health satisfaction would do. In other words, we estimate the income equivalent of health changes. Next, the health satisfaction changes are linked to specific diseases in order to estimate the income equivalent for various diseases. This method uses answers to well-being and health satisfaction questions as posed in a large German data set. We distinguish between workers and non-workers and between inhabitants of East- and West- Germany. We find, for instance, that for West-workers hearing impediments are on average equivalent to an income reduction of about 20%, and that heart blood difficulties are for the same group equivalent to a 47% income reduction.

Keywords: chronic diseases, equivalent income, health damages, health satisfaction, well-being.

JEL classification: I10, I12.

1. Introduction

One of the dominant issues in Health Economics is the evaluation of health changes. Health policy decisions are often evaluated in terms of costs and benefits, including opportunity costs. A second field where the evaluation of health is becoming increasingly important is that of health damage insurance and lawsuits. Injured individuals have to be compensated for their health losses including intangible damages.

The costs associated with an illness, or the benefits of recovering from it, are of diverse nature. First, there are *economic* costs associated with medical care, informal care in the household, or income losses due to working absence. Second, there are *intangible* costs , the monetary countervalue of the loss of health *per se*. They are mostly ignored or only mentioned without quantification. However, it is felt that they may be quite substantial. In this paper we present a method, which focuses on the intangibles.

Health economists usually assume that satisfaction with health (or health utility) can be measured. It is mostly measured on a bounded scale between 0 and 1, where 0 is the value assigned to the status of death and 1 to living perfectly healthy [1]. Between these extremes, researchers try to find values for different health states. Health quality is measured frequently in Quality Adjusted Life Years (QALY). There are various methods to operationalise and quantify health-*utility* and health-*utility* changes. One of the methods to evaluate health levels in terms of QALY's is by means of observing the answers to 'self-reported' health questions posed to people with the disease, or to a random group of people including but not restricted to sufferers from the disease [2,3,4,5]. Other measurement procedures are based on the Standard Gamble method and the Time Trade-Off method. One can compare therapies and diseases in terms of health-*utility* change per dollar spent, i.e. performing cost-utility analysis. Alternatively, one can translate the health-*utility* changes in monetary values. For instance, by looking at the decrease in productivity due to the deterioration of health [6]. It is evident that there is no uniformly accepted QALY –operationalisation and that in practice the results very according to measurement method used. A second approach which is used in health economics, but which is also very popular in environmental economics is the so – called Willingness to Pay method (WTP). In this approach individuals are asked how much money they would be willing to pay for not having the illness or its symptoms or for not having the unpleasant experience caused by the pollution of the environment. In practice the results of this method depend on the specific setting, the wording of the questions and the suspicion of the respondent that by strategic response behaviour he can influence his circumstances or the amount of monetary compensation. The mirror image is to ask for the Willingness to Accept (WTA). The two amounts should be equal in theory but this is rarely the case in practice. There is no uniformly accepted WTP–operationalisation and in practice the results vary according to the measurement method used.

In this paper, we develop an alternative method for measuring and monetarising health changes. The approach can be summarised as follows. Health satisfaction is seen as *one* of the domains of life. Other domains include financial satisfaction and job satisfaction. Individual well-being or General Satisfaction (GS) is then assumed to depend on the various domains of life satisfaction (DS). General Satisfaction (GS) and all Domain Satisfactions (DS) are measured subjectively, i.e. using individual answers to subjective questions posed in questionnaires. Recently, we estimated a structural model for individuals' well-being [7,8]. Building on that model, we assess the impact on general satisfaction of a change in health via changes in health satisfaction. We then estimate the equivalent income change that would be necessary to change general satisfaction to the same extent. In microeconomic vocabulary, we look for the *income equivalent* variation of health changes. The empirical analysis of the GS model is based on a large German panel data set (GSOEP), which we combine with results of Cutler and Robertson [3] and Groot [5]. Their papers present estimates of the impact of chronic diseases on individual health satisfaction estimated from an American and a British micro – data set respectively. They call those impact coefficients QALY weights. Assuming that the results for the US and for the UK will be roughly similar for Germany, we pool the German data set with the American and British estimates. The reason for doing this is that similar information is not available in the German data set. Given the synthetic character of the data set, the main objective of this paper is its methodological contribution, although we conjecture that the German data ,if available, would have resulted in similar income equivalents.

This paper is organised as follows. Section 2 presents the model. Section 3 describes the data. Section 4 shows the estimates of the model. Section 5 introduces the relevant money values of health gains and losses. Section 6 concludes.

2. The Model

In this section, we outline our model in simple terms. Let us assume that the individual's well-being depends on only two variables, viz., income y and health H. In that case we may describe well-being as a function of y and H, say

$$W = W(y, H) \tag{1}$$

Indifference curves in the (y, H)-space are sketched in Figure 1. The slope of these indifference curves reflects the shadow price of health. More precisely, we look for the income reduction, say Δy, which is equivalent to a deterioration of health, say by ΔH.

[Figure 1 about here]

Consider an individual at A, who experiences a health loss bringing him down to D. The monetary equivalent may be measured in two ways. The income change equivalent with the health loss AD is the income loss AC. We call this the *equivalent income variation*. In our case it is measured in terms of a percentage of original income. The equivalent income variation amount is found by solving the equation

$$W(y, H + \Delta H) = W(y + \Delta y, H) \tag{2}$$

When ΔH tends to zero we find the so-called shadow price of health

$$\left.\frac{dy}{dH}\right|_{welfare\,const.} = -\frac{dW}{dH} \Big/ \frac{dW}{dy} \tag{3}$$

The second way is to look for the additional income DB, needed to bring the individual back to his or her original level of well-being. We call this the *compensating income variation*. We notice that this shadow price is the slope of the indifference curve. Hence, it varies with the point (y, H) of departure. Moreover, if the indifference curves are not homothetic, the shadow price depends on the level of the indifference curve, say W, as well.

The function W is not assumed to be a cardinal utility function. The only use of W is that it describes the net of indifference curves. Any monotonic transformation $\tilde{W} = j(W)$ with $dj/\partial W > 0$ will describe the same net of indifference curves and thus will yield the same shadow prices.

Until now individual's well-being depended only on *y* and *H*. When describing this abstract model, however, we have in mind a more complex model, which was recently estimated for a large German household panel survey [7,8]. We shall refer to that study as PFF. Actually, the estimated outcomes of that study can be used for the present study .

In the model we assume that well-being or, as we call it in PFF, General Satisfaction (GS) depends on a vector of *domain* satisfactions (DS). These are qualitative and ordinal variables. On its turn the domain satisfactions may be explained by quantitative objectively measured variables such as income, age, and education.

In the German survey there are satisfaction questions with respect to six domains of life: Financial satisfaction (FS), Health satisfaction (HS), Job satisfaction (JS), Leisure satisfaction (LS), Housing satisfaction (HoS), and Environmental satisfaction (ES).

The model can be described as

$$GS = GS(DS_1, ..., DS_6) \qquad (4)$$

$$DS_j = DS_j(x) \quad j = 1,...,6 \qquad (5)$$

General Satisfaction (GS) is considered as an aggregate of the domain satisfactions (DS).

The model is graphically illustrated in Figure 2.

[Figure 2 about here]

Detailed specifications and the estimated model, as far as relevant for the present subject, will be shown in Section 4. What is relevant for this paper is that GS (after suitable specification) can be modelled and explained according to the equation

$$GS = g_1 JS + g_2 FS + g_3 HoS + g_4 HS + g_5 LS + g_6 ES + e \qquad (6)$$

Equation (6) describes the net of indifference curves; in this paper we are specially interested in the trade-off between health satisfaction and income. Let Health Satisfaction (HS) be reduced by ΔHS, then we may keep GS constant by increasing Financial Satisfaction (FS) by $\frac{g_4}{g_2}\Delta HS$. Income increases have a positive effect on financial satisfaction (FS). Actually income has an effect on *all* six domain satisfactions, including health itself [9]. Hence, in order to calculate the income decrease equivalent to a reduction of HS, we have to include and add up all indirect effects, i.e. the effects via *all* DS (see Figure 2).

In order to make the calculation method applicable in practice, we have to specify ΔHS numerically. In other words, we have to specify the health *change* from a base situation in a 0 to 10 scale, where we use the cardinal specification from the survey questionnaire. If we can translate the effect caused by real diseases into changes in HS, then it is also possible to calculate the money value of health damage, due to those diseases such as 'difficulty in seeing', and 'diabetes'. This step, where we will borrow US and UK estimates, will be presented in Section 5.

An obvious question is why we choose for this *indirect* model rather than for a straightforward model in which General Satisfaction is *directly* explained by objectively measurable variables x. This would imply that our function *W(.)* would not have health satisfaction *HS* as an argument but the underlying variables which determine health, e.g., the variables which describe the prevalence of chronic illnesses. This model, however, would give difficulties, for many variables have a different effect on different domains and the balance effect on GS is difficult to measure and to interpret. For instance, age may be assumed to have a negative effect on health, while age (up to a certain point) has a positive effect on income and hence presumably on welfare. By the use of the intermediary variables *DS* we are able to identify the different influences of the various x-variables via the different domains on GS and thus we get a more exact picture of the complex phenomenon. A second reason why we choose this somewhat complex model is that in the literature there are estimates available of the effects of illnesses on Health Satisfaction but not on the effect of illnesses on General Satisfaction [1].

3. Description of the Data.

For the empirical analysis of the structure of well-being, we make use of the German Socio-Economic Panel (GSOEP) [11]. The GSOEP is a longitudinal household panel, which was started in the Federal Republic of Germany in 1984. After the reunion

[1] We know of one exception with respect to migraine. See Groot and Maassen van den Brink [10]

East-German households have also been included. In [7,8] we developed and estimated a 'structural' model of well-being.

Our data set covers more than 19,000 individuals of which about 30% are Eastern individuals. We studied the period from 1992 to 1997. The two regions of the country have separately lived under very different regimes for 45 years. Although there is a continuous process of adaptation to the West, it seems warranted to consider the two sub-samples over the period considered as reflecting two populations. A considerable part of the respondents are non-working. Also here we thought it was wise to consider them as different populations, given the scope of our study. About 30% of Western non-workers are 65 years old or older, and 65% are females. For the Eastern non-workers, these percentages are 26% and 62% respectively. So we ended up with four sub-panels of individuals.

It is conceivable that Easterners move to the West and reversely or that individuals without a job a get paid work. Those transitions are, however, fairly rare [12,13], so we preferred to define a respondent who switches from one status (regional or employment-wise) to another as a new respondent in the new group.

The GSOEP-survey is interesting to us as it contains a set of subjective satisfaction questions with respect to DS. They run like this:

'How satisfied are you today with the following areas of your life?

(Please answer by using the following scale, in which 0 means totally unhappy and 10 means totally happy)

How satisfied are you with your

Health ……………………………………………………………

Job ……………………………………………………………

Income ……………………………………………………………

Dwelling ……………………………………………………………

Free-time……………………………………………………………

Environmental condition in your area………………………… '

A similar question is asked with respect to 'life as a whole'. [cf. 14]. Such subjective questions are now standard in psychological and sociological surveys [c.f.15]. In the GSOEP, this GS question runs as follows:

And finally, we would like to ask you about your satisfaction with your life in general. Please answer by using the following scale, in which 0 means totally unhappy, and 10 means totally happy.

How happy are you at present with your life as a whole? _____

Table 1 presents some summary statistics of the data. Satisfactions are on a 0 to 10 scale. Table 1 also presents also the household monthly net income in German Marks.

[Table 1 about here]

4. The Estimated Model.

In order to explain GS , we need a cardinalisation of the DS variables. Here, we face a problem, because there is no generally accepted cardinalisation. In the questionnaire there is chosen for a discrete cardinalisation into 0,1,…,10, but this is *just one* cardinalisation. For the analysis of the paper, we are interested in the trade- off –ratios between the DS. They describe, for instance, which increase in Financial Satisfaction compensates a specific decrease in Health Satisfaction in terms of General Satisfaction. We shall now show that the choice of the cardinalisation of the DS is raher irrelevant. Let us assume that GS may be described by the equation

$$GS = g_1 DS_1 + g_2 DS_2 \tag{7}$$

The trade- off- ratio between DS_1 and DS_2 ,when keeping GS, constant, is

$$\left(\partial DS_1 \big/ \partial DS_2 \right)_{GS=constant} = g_2 \big/ g_1 \tag{8}$$

Let us now consider a second cardinalisation, which is a monotonic function of the first. We define

$$D\breve{S}_i = f_i(DS_i) \quad i = 1,2 \tag{9}$$

With respect to the second cardinalisation the previous equation is rewritten as

$$GS = g_1 f_1^{-1}(D\breve{S}_1) + g_2 f_2^{-1}(D\breve{S}_2) \qquad = g_1 f_1^{-1}(f_1(DS_1)) + g_2 f_2^{-1}(f_2(DS_2)) \tag{10}$$

We see that GS in terms of the *second* cardinalisation will be non – linear, when one or both ‘translation’ rules f are non- linear. However, if we apply the chain rule , we see that we get the same trade – off ratio with respect to the *first* cardinalisation. The coefficients of the DS depend on the cardinalisation rule applied to DS. Nevertheless, whether we explain GS in terms of the first or second cardinalisation is immaterial with respect to the value of the trade – off ratio. Hence, it is just a matter of econometric convenience which cardinalisation we apply to explain GS from domain satisfactions. Given the fact that in a Probit (or regression) model it is undesirable to use bounded explanatory variables, we cardinalise the DS such that their range is the whole real axis. Terza [16] describes a method to cardinalize qualitative variables, such that they can be used as explanatory variables in a regression (or Probit) equation. We apply the ‘translation’ - method proposed by Terza, but other methods are also conceivable. Terza’s method runs as follows.

Let there be *k ordered classes* of the variable *DS*, then we denote the class frequencies by $p_1,\ldots,p_k$ and we the intercepts m by the following equations

$$\begin{aligned} N(m_1) &= p_1 \\ N(m_2) &= p_1 + p_2 \\ &\ldots\ldots\ldots \end{aligned} \tag{11}$$

Then we define the values

$$\ddot{DS}(i) = E(Y | m_{i-1} \le Y \le m_i) \tag{12}$$

where the expectation is taken with respect to the $N(0,1)$ – distribution [17]. These values are used as explanatory variables in eq.(8). We notice that this translation rule does not depend on individual characteristics of the respondent. We shall not dwell on this translation rule as it is clear from the above that the translation rule is in fact irrelevant, provided that there is one.

Equations (4) and (5) in Section 2 describe the model. Here, we present the estimation method. We refer to [7] for a more detailed description. We start with the estimation of (4). As the data set covers 6 consecutive years, we include 5 time dummies C_t (time fix effects). In order to account for the individual unobserved component we introduce individual random effects. Hence, the disturbance term for individual n, and time t is

$$e_{nt} = v_n + h_{nt} \qquad (13)$$

where v_n is the individual random effect. We postulate the usual assumptions, i.e. $E(v) = E(h) = 0$, $s^2(h) = 1$ and $Cov(v, h) = 0$. Both h and v are normally distributed. As usual in Ordered Probit, we normalise by $s^2(e) = s^2(v) + 1$. We notice that, due to the individual random effect, $s^2(e)$ is not equal to one, as standard in probit analysis, but it equals $s^2(v) + 1$, where $s^2(v)$ has to be estimated. The fact that we have to apply ordered Probit analysis on panel data, makes the analysis technically more difficult. However, it is possible to estimate ordered probit equations on a panel, including individual random effects. We use LIMDEP 7.0 for this job.

Similarly to the decomposition of e into a time-variable and a time-constant component, it is attractive to decompose the Domain Satisfaction into their mean over the observation period and the deviation from that mean, that is

$$DS_{nkt} = \overline{DS}_{kn} + (DS_{nkt} - \overline{DS}_{kn}) \qquad (14)$$

The inclusion of $\overline{DS}$ is interpreted by [18] as picking up the correlation between the individual random effect and the explanatory variables. Here, we interpret $\overline{DS}$ as the effect that the mean income has independently of the effect of the deviations from it. A second but complementary interpretation is a decomposition into a *level* and a *shock* effect, as for instance Friedman's (1957) income decomposition into a permanent and a transitory component.

For GS, we specify and estimate the General Satisfaction equation by Ordered Probit. We postulate,

$$GS_{nt} = g_1 D\ddot{S}_{1nt} + ... + g_6 D\ddot{S}_{6nt} + d' D\bar{\ddot{S}}_n + l \; Z_n + e_{nt} \qquad (15)$$

Here we introduce an auxiliary variable *Z.* Actually ,we may assume that there is an element which influences *both* $D\ddot{S}$ *and GS.* It is a personality trait. There are individuals, who have an optimist character and see things from the 'sunny side', while others are always pessimistic and inclined to downrate their situation. If such a factor is present, it will be included in the error terms of the *DS* and in the error term of *GS*.. In that case the explanatory variables *DS* will be correlated with the *GS*-error, which will cause an endogeneity bias. Hence, we have to construct an additional explanatory variable Z_n ,which represents this latent trait. How this variable has been constructed, we will explain below when we consider the *DS* more in detail.

Similarly, we estimate the six DS. It is intuitively obvious that the six domain satisfactions $D\ddot{S}_j \, (j = 1,...6)$ depend on objectively measurable variables such as *age,* and *income*. The $D\ddot{S}_j$ are not categorical variables such as the GS but are values on the real axis. Thus, we estimate the domain satisfactions by OLS regression equations

$$D\ddot{S}_{jnt} = C_t + b_j^{'} x_{nt} + a_j \bar{x}_n + e_{jnt} + h_{jn} \qquad j = 1, \ldots, 6, \qquad (16)$$

Because (16) is estimated by OLS, $s^2(e_{jnt})$ is not assumed to be equal to 1 but it has to be estimated by the model. We notice that each equation may be separately estimated by OLS using standard panel econometrics. It is rather probable that the six error terms are correlated, which would point to a Seemingly Unrelated Regression model. However, it is well – known that in this case simple OLS regressions yield also consistent estimates for the separate equations. As all the explanatory variables are exogenous, there are no identification difficulties, even if each of the six equations would have the same set of explanatory variables. This, however, is not the case. It might be argued that the structure is essentially more complex as one domain satisfaction may affect another. For instance, Health Satisfaction may explain Job Satisfaction or *vice versa* [19]. Then we would have a block of simultaneous equations with the usual identification pitfalls. However, we are not interested here in the structural model but only in the reduced model. We interpret the equation block as a reduced model.

Let us now return to the construction of the variable *Z*, which we introduced in the *GS* – equation (15). We may assume that this is also an explanatory variable for the *DS* . As it is omitted it is a component for the residual. More precisely we may assume

$$e_{nit} = q_i \hat{Z}_n + v_{ni} + h_{nit} \quad (17)$$

where the variable $\hat{Z}_n$ is present in each domain error term with a domain specific effect q_i. A similar structure will hold for the calculated residuals, although the Z – effect will be partly annulled due to its correlation with the included explanatory variables. Hence, we may construct a variable *Z*, which varies proportionally with the latent $\hat{Z}_n$ by adding all the 36 domain residuals per individual. The variables n *and* e will average out while the individually constant *Z* will not average out.

It is this Z - construct which is used in the *GS* – estimation. We see that the effect of this variable is quite significant. A comparison of the estimated equation *with* and *without* the addition of *Z* shows that all the coefficients of DS are considerably reduced if the term is added but that this reduction is by approximately the same factor, such that the trade – off ratios are only marginally changed. All coefficients stay significant. The same holds for the mean *DS.* We do not reproduce this comparison at this place but the tables can be asked from the authors. The coefficient of *Z* is a weighted covariance between the domain error terms and the GS- error. The whole procedure is a kind of Heckman correction [20]. In this way we eliminate the endogeneity bias. Moreover, we annul the covariance between the error terms and we may deal with the recursive system under the assumption that the error covariance matrix is diagonal (see e.g. Greene(2000),p.675)).

5. Estimation Results

This section presents the estimation results for equation (15) and (16). In Table 2 we present the estimates for the GS-equation where we include all the six domain satisfactions ($\ddot{DS}$) and their means over the six – year period. The first column gives the estimated coefficients for Western workers, while the second column displays the t-values. The other columns give the corresponding values for Eastern workers, Western non-workers, and Eastern non-workers respectively.

The most interesting coefficients are the domain coefficients. We see the shock effects in the first block, while the level effects are the sum of the shock effects and the coefficients of the corresponding 'mean' – variables. So we find for a Western worker that the *level* effect of job satisfaction on general satisfaction is $0.265+0.087=0.352$, while the shock effect is 0.265. We see that all domain effects are strongly significant. Given the ordinal character of the DS – variables, it is impossible to compare the effects of the DS directly. In three of the four equations Z has a significant negative coefficient. If we estimate the equation without Z, we find smaller coefficients of the DS – variables, although the trade off ratios remain virtually unchanged.

The relative contribution of the individual random effect to the total variance, that is $s^2(n) \big/ 1+s^2(n)$, turns out to be fairly large at about 25 to 31%. This equals also the intertemporal correlation coefficient between the errors .

Next, we discuss the results for the DS equations. There is a growing body of literature that examines subjective well-being questions [21, 22, 23] for specific domains. In this context it is impossible to present and discuss all six domain satisfactions equations (see PFF). We restrict ourselves to the presentation of the equations for Health Satisfaction and Financial Satisfaction.

[Table 3 about here]

Table 3 presents the results for the Financial Satisfaction equation. We see that financial satisfaction depends on income in two ways. First there is a dependency on mean (ln(family income)), which resembles Friedman's [24] permanent income concept. Second there is an effect of current income. For West workers the relevant income effect is

$$0.120x_{nt} + 0.262\bar{x}_n = 0.120(x_{nt} - \bar{x}_n) + 0.382\bar{x}_n \qquad (18)$$

The coefficient 0.120 is the *shock* effect and 0.382 is the *level* effect. The level effect are the effects that we shall use in our calculations in section 5. Apart from income we see a strong age effect which is parabolic in ln-age. Satisfaction falls with age under *ceteris paribus* conditions and reaches for Western workers a minimum at the age of 44. There is a notable effect of education: for Westerners, financial satisfaction rises with their education level. For Easterners the effect is non-significant (workers) or even strongly negative (non-workers). For workers, the number of adults in the household has a strong negative effect. For Westerners, the number of children has also a negative impact on FS. Moreover, we notice that the effect of income on FS becomes larger as one has more children to maintain (see the interaction term). Males are less satisfied than females and living together with a partner increases one's satisfaction with the financial situation. The presence of more than one income earner in the household has a slight negative non-significant effect. Having savings makes one feel better.

Table 4 presents the results for Health Satisfaction. Table 4 shows that income correlates positively with health satisfaction. The positive correlation between income and health is well accepted [9,25]. Nevertheless, the current income coefficients are not significant. The mean income coefficients are all positive but significant at 10% only for Westerners. This points to the hypothesis that income in this equation serves as a proxy for lifestyle and becomes important only, when more direct descriptors of lifestyle are not included in the set of explanatory variables. A family with a lower income will have a lifestyle and a risk-behaviour that is more damaging to health (for instance, smoking, drinking, or obesity) and usually will be living in less healthy environments. The current income would approximate the access that individuals have to doctors and medicine. Thus, our results seem to indicate that the life-style effect is more important for health satisfaction (and status) than the income *per se*. It is also true that less healthy individuals are less productive and, as a consequence, have lower earnings. Therefore, the direction of the causality between health and income is not always clear [25]. Age is an important determinant for health satisfaction, i.e., younger people are more satisfied with their health (see also [26]). Education correlates significantly and positively with health satisfaction. Again, well educated people have most probably lifestyles that are healthier (see also [26]) and thus education could be indicating life-style. The average number of children has a positive and significant effect for Easter non-workers, while the effect is non-significant for the other three groups. Kerkhofs and Lindeboom [26] using Dutch data for 1993 studied the influence of exogenous variables on mis-reporting health status. They found that labour market status was the only variable that had a significant effect on mis-reporting. This would support the division of the sample in four sub-groups.

The variance of v is more than 50% of the total residual variance. In order to compare our health satisfaction coefficients with a cross-section ordered probit, the coefficients of Table 3 need to be multiplied by about 0.8 or 0.9 depending on the sub-sample.

6. The monetary value of a health change

In Section 5 we estimated General Satisfaction as a function of six domain satisfactions and of various objectively measurable variables. Similarly, the six domain satisfactions are explained by objective variables... The level effects of the six domain satisfactions on General Satisfaction are tabulated in Table 5.

[Table 5 about here]

We notice that the level effect of health satisfaction for West-workers is 0.501,i.e. 0.324+0.177. This implies that if health satisfaction is reduced by ΔHS , GS decreases by $0.501\,\Delta HS$. Thus, it is possible to translate such a health loss in terms of an equivalent income loss Δy .

The effect of ln-income changes on GS is fairly complex in this model, as income appears as one of the explanatory variables in *each* DS. Hence, there are six indirect effects . All those six ln-income effects are tabulated in Table 6.

[Table 6 about here]

Hence, the effect of an income change on GS via job satisfaction is $0.352 * 0.084$. Let us denote a column in Table 5 by $a_1,...a_6$ and the corresponding column of Table 6 by

$b_1,...b_6$, then the total income effect on GS (for each sub-sample) will be

$$\sum_{i=1}^{6} a_i b_i \tag{19}$$

Then we may calculate the relative income change, $\Delta \ln y$, that is equivalent to a change in health satisfaction by ΔHS. For West Workers, this is found by solving the equation

$$0.501 \ \Delta HS = \left(\sum_{j=1}^{j=6} a_j b_j \right) \Delta \ln y \tag{20}$$

which yields

$$\Delta \ln y = \frac{0.501}{\sum_{j=1}^{j=6} a_j b_j} \Delta HS \tag{21}$$

We shall denote the value of the multiplier in equation (21) by k. The values for the four sub-samples, say k_{ww}, k_{ew}, k_{wnw}, and k_{enw} are given below in Table 7.

[Table 7 about here]

The remaining question is how to translate health changes, for instance caused by an illness such as diabetes, into a numerical value of ΔHS. An obvious way would be to re-estimate the equation for health satisfaction where we include a disease-dummy variable, which is zero for a healthy person and one for an individual with the disease.. Unfortunately, in our German data set we do not have this information. Instead we make use of the estimates recently found by Cutler and Richardson [3] for US data and by Groot [5] for British data. They estimated a health satisfaction equation by Ordered Probit, which include dummy variables for various illnesses. Obviously a strong *caveat* is that we extrapolate health effects estimated from British and USA respondents to Germans. Moreover, these effects have been estimated on the basis of a different functional specification. Nevertheless, for a first illustration, lacking better, it will do. We also notice that the estimates of Groot [5] and of Cutler and Richardson [3] yield roughly comparable disease effects, which makes it probable that the figures may also hold approximately for German respondents. An additional limitation is that the illnesses among individuals are not differentiated according to the degree of severity. In other words, individuals with, e.g., diabetes have the dummy variable 'diabetes' equal to 1 regardless of the severity of the 'diabetes' they suffer from.

The equivalent income variation (AC in Figure 1) is $(1 - e^{k*d})$, where d is the coefficient of the disease on HS. The results of k are presented in Table 7, and the values of *d*, borrowed from Cutler and Richardson [3] and Groot [5], are presented in Table 8. The Health satisfaction equation in our model has a residual variance, which differs from that in Cutler and Richardson [3] and Groot [5]. Their residual variance is equal to 1 by the Probit- normalization convention. In our case, it equals the sum of the error term and the individual random effect. In order to correct for that, the coefficient estimates of Cutler and Richardson [3] and Groot [5] have to be multiplied by a correction factor ,which is given in the last row in Tables 8 and 9.

[Table 8 about here]

[Table 9 about here]

In Table 8 and Table 9, we present estimates for the equivalent income variations for various diseases.

Table 8 and Table 9 show that working individuals living in the West who, for example, get problems in hearing, suffer a decline on well-being equivalent to a reduction of their income by 17.6% when using Cutler's and Robertson's estimates, and 20% when using Groot's estimates. If the individual is not working, these percentages would be higher and equal 22.6% and 26% respectively. Similarly, the Eastern workers experience a lower relative income equivalent reduction than the Eastern non-workers for any given illness. The differences between Easterners and Westerners are also rather considerable, being higher for Working Westerners in comparison to Working Easterners, and for Non-working Easterners in comparison to Non-Working Westerners. A critical illness such as diabetes would decrease Western working individuals' well-being as much as reducing income by 59%, with Cutler and Richardson estimates, and 41% if using Groot's estimates.

Since the income equivalent is estimated as a percentage of income, it follows that individuals with higher income have, in absolute terms, a higher income equivalent for a health deterioration. The logarithmic specification of income, which causes this effect, is well accepted in utility theory, and in agreement with results in experimental psychology. In the field of income taxation it is the reason behind progressive taxation. This does not imply that society has to value the health of richer individuals more that of poorer ones. ,The interested reader should notice that other complementary or alternative approaches such as monetary valuation of a life-year by means of on-going economic production, or WTP valued by means of CVM, lead also to health valuations that depend on the income of the individual.

7. Discussion and Conclusion

In this study, we addressed the question of what is the value of health gains and losses, expressed in monetary terms. The subject has a long history in health economics. Torrance [27] in his now classical exposition distinguishes between 'economic benefits' and the 'value of health improvement per se'. It is 'the value to the patient, family or society of the health improvement itself, regardless of any economic consequences'.

There is a well-established protocol on how to assess the 'economic benefits', although there are still a lot of unsolved problems, where *ad hoc* decisions have to be made. The second type of benefits, also sometimes called 'intangibles', is still much more problematic, although it is generally felt that it is an important component as well. Neglect of this component 'because we do not know how to measure it' leads to a gross under valuation of health deterioration. When we look for the value of a health gain or loss the first question is who is the evaluator: the individual him or herself, the medical doctor, the family, or society? In our approach we focus on the individual, although we do not ignore that other parties are also involved. The persons themselves, however, are the only ones who can assess the *subjective* value of a health gain or loss. If other parties also benefit, for example, from the health improvement of a beloved person, their indirect benefit will be necessarily a function of the improvement the patient him or herself perceives. So we think that the information from self-reporting health gains and losses stands central in the question of how to evaluate changes in health.

Now there are two approaches to value health in monetary terms. The first one is to assess the health change by means of a specific health scale. Here typically, the worst situation (mostly 'dead') is evaluated by zero and the best health by one. This is the so-called QALY-approach. We can say that a person's health has been improved by 0.20 QALY. A second stage is then to relate the money cost of the therapy with the QALY-gain, yielding a QALY per dollar output measure. In health economics there is not a generally accepted method of QALY measurement. Cutler and Richardson [3], quoting Neumann et al. [28] remark that 40% of the measurements are based on the subjective opinion of the doctor. Hence QALY-measurements from different studies are difficult to compare. If we wish to monetarise health in order to perform CBA (Cost Benefit Analysis) we are faced with the question how to translate QALY's in money terms. Monetarisation is then realised by, for example, looking at the economic output forgone per year (see, for example, [6,29]). A second approach to asses the monetary value of health is by a WTP study. This approach and its limitations are discussed in the health economics [6] and environmental economics literature [30].

Our approach is of a different flavour. What we really need is an (ordinal) utility function $U(y,H)$ such that $\frac{dU}{dy} \big/ \frac{dU}{dH}$ is the trade-off, that is the shadow price of health in terms of money. If we have such an instrument, we have a 'money-metric ' [31] for health and we may circumvent the 'monetarisation of QALY'-problem. In this paper this is precisely what we have done. We have estimated an ordinal utility function, or rather the corresponding net of indifference curves, such that changes in health satisfaction can be evaluated in terms of changes in general satisfaction and hence in terms of money. So we escape the problem of cardinal utility measurement (needed for the QALY approach). At the same time we are in principle able (although we borrowed in this paper relevant figures from Cutler and Richardson , [3] and

Groot, [5]) to evaluate health changes caused by specific medical states /diseases in terms of an ordinal variable health and to link changes in health satisfaction with equivalent changes in income. This approach is particularly useful for valuing health when we focus on the individual (and not the society as a whole). Such is the case in health damage insurance or lawsuits, which are of increasing importance.

The present method is not intended to make the QALY-methodology redundant, but rather it must be seen as a complement to the QALY-method, with itself remains necessary for the evaluation of medical therapies in terms of health gains.

Obviously this method is in its initial stage and should be validated. Moreover a number of refinements may be conceived of. Nevertheless, we think these first results sufficiently promising to bring them to the attention of our colleagues.

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Figure 1: Indifference curves, health-income

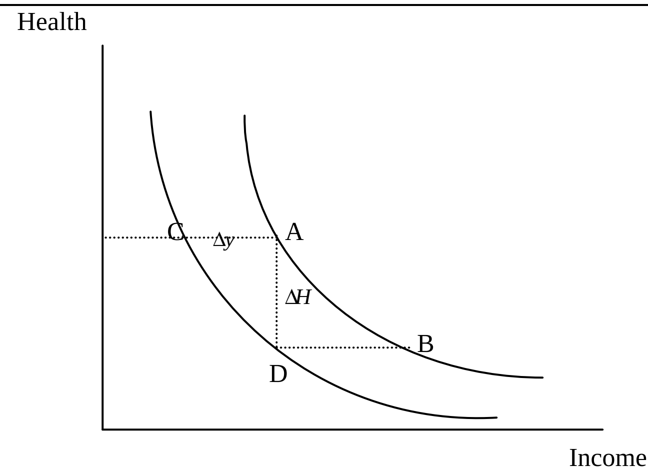

Figure 2: the effect of income on well-being

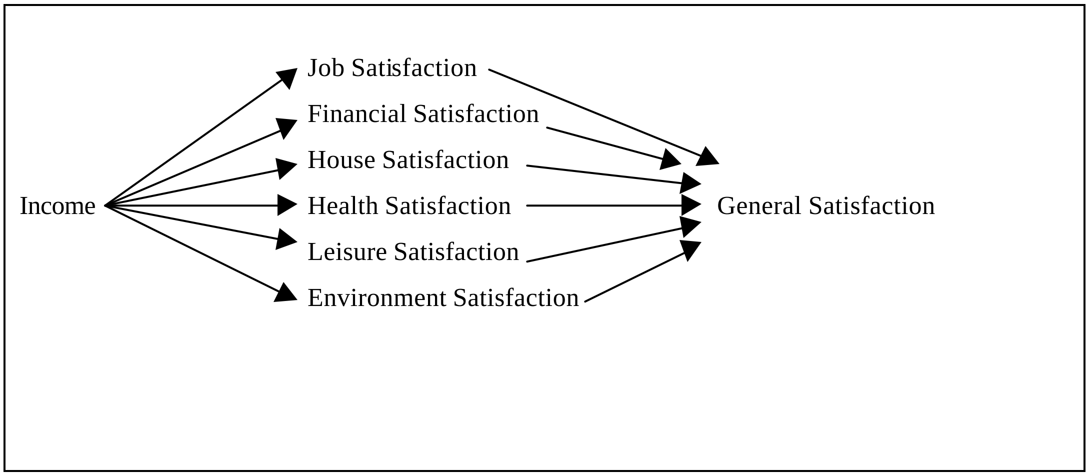

Table 1: Average and standard deviations of satisfaction levels and income in the GSOEP, 1992-1997

	West Workers	East Workers	West Non-Workers	East Non-Workers
General Satisfaction	7.21 (*1.632*)	6.46 (*1.615*)	6.95 (*1.947*)	6.12 (*1.970*)
Job Satisfaction	7.15 (*1.972*)	6.83 (*2.074*)		
Financial Satisfaction	7.09 (*1.887*)	6.28 (*1.890*)	6.99 (*2.120*)	6.12 (*2.136*)
Housing Satisfaction	7.42 (*2.145*)	6.66 (*2.297*)	7.57 (*2.186*)	6.96 (*2.319*)
Health Satisfaction	7.06 (*2.073*)	6.90 (*1.941*)	6.27 (*2.484*)	5.94 (*2.364*)
Leisure Satisfaction	6.40 (*2.318*)	5.89 (*2.392*)	7.48 (*2.235*)	7.18 (*2.245*)
Environment Satisfaction	6.26 (*2.008*)	4.99 (*2.073*)	3.68 (*2.065*)	5.13 (*2.174*)
Net Family Income (monthly in DM)	4034 (*2150*)	3393 (*1516*)	3115 (*2014*)	2438 (*1318*)
Number of Observations	29099	11668	19965	8021

Table 2: General Satisfaction

Ordered Probit with Individual Random Effect and Fix Time Effects

	West Workers		East Workers		West Non-Workers		East Non-Workers	
	Estimate	Estimate/ Std. Error	Estimate.	Estimate/ Std. Error	Estimate	Estimate/ Std. Error	Estimate.	Estimate/ Std. Error
Constant	4.147	86.317	4.774	52.202	3.860	87.905	4.098	59.593
Dummy for 1992	0.250	10.212	-0.011	-0.289	0.220	7.670	-0.039	-0.837
Dummy for 1993	0.189	8.268	-0.046	-1.248	0.184	6.677	-0.090	-2.152
Dummy for 1994	0.118	4.961	0.078	2.128	-0.007	-0.235	-0.245	-5.575
Dummy for 1995	0.139	6.085	0.151	3.981	0.064	2.401	-0.058	-1.308
Dummy for 1996	0.121	5.140	0.116	3.031	0.068	2.497	0.048	1.098
Job Satisfaction	0.265	17.128	0.376	15.905	XXX	XXX	XXX	XXX
Finan. Satisfaction	0.244	15.954	0.383	15.855	0.243	15.003	0.455	16.000
House Satisfaction	0.146	9.607	0.238	9.748	0.178	9.482	0.387	12.739
Health Satisfaction	0.324	20.481	0.297	11.494	0.448	25.395	0.548	17.800
Leis. Satisfaction	0.125	8.050	0.168	6.725	0.168	9.206	0.354	12.396
Envir. Satisfaction	0.093	5.964	0.186	7.270	0.138	7.894	0.293	10.131
Mean (Job S.)	0.087	5.316	0.053	2.081	XXX	XXX	XXX	XXX
Mean (Financial S.)	0.393	21.416	0.476	15.899	0.517	27.413	0.441	14.847
Mean (House S.)	0.002	0.130	-0.054	-2.068	0.022	1.026	-0.060	-2.013
Mean (Health S.)	0.177	10.733	0.148	5.092	0.210	12.808	0.111	3.965
Mean (Leisure S.)	0.099	6.049	0.101	3.772	0.014	0.736	0.181	6.310
Mean (Environ. S.)	-0.043	-2.613	0.038	1.389	-0.072	-3.805	0.018	0.617
Z	-0.067	-0.923	-0.587	-5.041	-0.278	-3.475	-1.411	-9.986
Std Deviation v_i	0.593	66.788	0.585	38.602	0.673	58.187	0.628	34.186
Variance due to v_i as % of the total variance	0.260		0.255		0.312		0.283	
Number Observations	29636		11941		20427		8335	
Log Likelihood	-43444		-18303		-33125		-14321	
LogLik/Observation	-1.466		-1.533		-1.622		-1.718	
Num. Of Individuals	7995		3157		6353		2651	

* This is the minimum of the quadratic form in ln(age).

Table 3: Financial Satisfaction

OLS with Individual Random Effect and Fix Time Effects

	West Workers		East Workers		West Non-Workers		East Non-Workers	
	Estimate	Estimate/ Std. Dev	Estimate.	Estimate/ Std. Dev	Estimate	Estimate/ Std. Dev	Estimate.	Estimate/ Std. Dev
Constant	1.815	*2.081*	1.404	*1.03*	8.473	*11.348*	10.549	*8.917*
Dummy for 1992	0.214	*13.308*	-0.076	*-2.904*	0.078	*3.800*	-0.232	*-6.485*
Dummy for 1993	0.105	*6.352*	0.007	*0.248*	0.117	*5.493*	-0.140	*-4.171*
Dummy for 1994	0.054	*3.266*	-0.288	*-11.195*	0.181	*8.583*	-0.021	*-0.641*
Dummy for 1995	0.035	*2.146*	-0.030	*-1.189*	0.117	*5.715*	-0.012	*-0.369*
Dummy for 1996	0.015	*0.846*	-0.025	*-0.932*	0.021	*0.923*	-0.081	*-2.302*
Ln(age)	-2.830	*-5.71*	-2.677	*-3.455*	-6.833	*-16.667*	-7.255	*-11.337*
Ln(age) ^ 2	0.373	*5.343*	0.336	*3.061*	0.941	*16.730*	0.992	*11.342*
*Min. Age**	44.596		53.876		37.791		38.684	
Ln(family income)	0.120	*5.496*	0.231	*6.109*	0.122	*4.397*	0.205	*4.077*
Ln(yrs. education)	0.116	*2.797*	-0.032	*-0.485*	0.141	*2.559*	-0.273	*-3.520*
Ln(adults)	-0.087	*-4.124*	-0.139	*-3.617*	-0.013	*-0.435*	-0.068	*-1.139*
Ln(children+1)	-0.359	*-1.731*	0.018	*0.052*	-0.341	*-1.409*	-0.289	*-0.607*
ln(f.inc.)*ln(ch.+1)	0.038	*1.551*	-0.021	*-0.493*	0.034	*1.143*	0.025	*0.426*
Gender	-0.023	*-1.394*	-0.037	*-1.698*	-0.152	*-7.159*	-0.086	*-3.015*
Ln(Savings)	0.015	*6.28*	0.017	*4.246*	0.018	*5.318*	0.024	*4.283*
Living together?	0.094	*4.777*	0.172	*4.267*	0.140	*7.192*	0.054	*1.528*
More than 1 Earner	-0.015	*-0.854*	-0.073	*-2.292*				
Mean (ln(f.inc)	0.262	*8.2*	0.225	*4.289*	0.291	*7.402*	0.157	*2.372*
Mean (ln(savings)	0.043	*9.899*	0.031	*4.614*	0.050	*8.858*	0.045	*5.137*
Mean (ln(ch+1))	-0.080	*-2.498*	-0.154	*-2.803*	-0.207	*-4.822*	-0.253	*-3.301*
Mean (ln(adults))	-0.065	*-2.283*	0.042	*0.893*	-0.127	*-3.212*	-0.023	*-0.324*
Std Deviation v_i	0.564		0.463		0.620		0.495	
Variance due to v_i as % of the total variance	0.745		0.287		0.386		0.279	
Number Observations	30622		12357		20867		8536	
R-squared: within	0.014		0.035		0.011		0.037	
R-squared: between	0.116		0.132		0.181		0.201	
R-squared: overall	0.074		0.080		0.146		0.142	
Num. Of Individuals	8148		3236		6419		2699	

* This is the minimum of the quadratic form in ln(age).

Table 4: Health Satisfaction

OLS with Individual Random Effect and Fix Time Effects

	West Workers		East Workers		West Non-Workers		East Non-Workers	
	Estimate	Estimate/ Std. Error	Estimate.	Estimate/ Std. Error	Estimate	Estimate/ Std. Error	Estimate.	Estimate/ Std. Error
Constant	-1.121	*-1.333*	-0.935	*-0.712*	5.254	*7.357*	2.731	*2.315*
Dummy for 1992	0.016	*1.148*	0.132	*6.366*	0.001	*0.037*	0.021	*0.746*
Dummy for 1993	-0.008	*-0.577*	0.109	*5.213*	0.021	*1.211*	0.053	*2.021*
Dummy for 1994	-0.002	*-0.139*	0.042	*2.050*	-0.003	*-0.179*	0.023	*0.914*
Dummy for 1995	-0.002	*-0.130*	0.039	*1.955*	0.000	*0.000*	-0.005	*-0.193*
Dummy for 1996	-0.035	*-2.374*	0.029	*1.329*	-0.001	*-0.031*	0.050	*1.803*
Ln(age)	0.852	*1.778*	0.627	*0.834*	-2.536	*-6.446*	-1.125	*-1.741*
Ln(age) ^ 2	-0.238	*-3.531*	-0.207	*-1.940*	0.210	*3.891*	0.023	*0.260*
*Max.Age**	5.976		4.560		424.307		4.E+10	
Ln(family income)	0.004	*0.232*	0.032	*1.175*	-0.009	*-0.456*	0.015	*0.399*
Ln(yrs. education)	0.131	*3.068*	0.193	*2.697*	0.233	*4.215*	0.273	*3.359*
Ln(children+1)	0.012	*0.063*	-0.147	*-0.494*	-0.222	*-1.067*	0.814	*1.999*
ln(f.inc.)*ln(ch.+1)	0.000	*0.005*	0.017	*0.469*	0.027	*1.060*	-0.095	*-1.862*
Gender	0.082	*4.928*	0.104	*4.301*	-0.001	*-0.025*	0.027	*0.878*
Living together?	-0.011	*-0.843*	0.017	*0.634*	0.044	*2.492*	-0.003	*-0.099*
Ln(Savings)	0.006	*2.748*	-0.002	*-0.480*	0.008	*3.014*	0.003	*0.582*
Mean (ln(f.inc)	0.097	*3.236*	0.071	*1.432*	0.069	*1.944*	0.020	*0.325*
Mean (ln(ch+1))	0.019	*0.773*	-0.096	*-2.209*	-0.012	*-0.395*	-0.149	*-2.690*
Mean (ln(savings)	0.018	*4.355*	0.014	*2.108*	0.020	*3.749*	0.017	*2.096*
Std Deviation v_i	0.643		0.595		0.702		0.658	
Variance due to v_i as % of the total variance	0.515		0.513		0.549		0.532	
Number Observations	30669		12359		20883		8532	
R-squared: within	0.008		0.023		0.006		0.009	
R-squared: between	0.126		0.124		0.274		0.262	
R-squared: overall	0.083		0.090		0.191		0.174	
Num. Of Individuals	8153		3238		6424		2705	

* This is the minimum of the quadratic form in ln(age).

Table 5: Level Effects of DS on GS

Level Effects	West Workers	East Workers	West Non-Workers	East Non-Workers
Job Satisfaction	0.352	0.429	XXX	XXX
Financial Satisfaction	0.637	0.859	0.760	0.896
House Satisfaction	0.148	0.184	0.200	0.327
Health Satisfaction	0.501	0.445	0.658	0.659
Leisure Satisfaction	0.224	0.269	0.182	0.535
Environmental Satisfaction	0.050	0.221	0.066	0.311

Table 6: Income effects on DS and GS

Level Income Effects on GS and on each DS	West Workers	East Workers	West Non-Workers	East Non-Workers
Job Satisfaction	0.238	0.247		
Financial Satisfaction	0.398	0.448	0.423	0.236
House Satisfaction	0.297	0.113	0.414	0.225
Health Satisfaction	0.101	0.110	0.068	0.016
Leisure Satisfaction	0.064	0.052	0.062	0.100
Environmental Satisfaction	0.211	0.186	0.108	0.043

Table 7: Health-income multipliers

	West Workers k_{ww}	East Workers k_{ew}	West Non-Workers k_{wnw}	East Non-Workers k_{enw}
Multiplier	1.098	0.723	1.409	1.819

Table 8: Value of Illness as % of current income (US)

Disease, Coefficients from Cutler and Richardson (1997), Corrected for Std. Deviation	West Workers	East Workers	West Non-Workers	East Non-Workers	Disease Coeff.
Arthritis	0.429	0.290	0.523	0.613	-0.578
Skin Conditions	0.263	0.170	0.332	0.404	-0.315
Diabetes	0.593	0.423	0.695	0.782	-0.927
Other endocrine	0.395	0.265	0.485	0.573	-0.518
Hypertension	0.305	0.200	0.381	0.460	-0.375
Ischemic heart disease	0.546	0.383	0.647	0.737	-0.814
Stroke	0.489	0.337	0.588	0.679	-0.692
Other circulatory	0.408	0.275	0.500	0.588	-0.541
Asthma	0.497	0.343	0.596	0.687	-0.708
Bronchitis	0.301	0.197	0.377	0.455	-0.37
Sinusitis	0.170	0.108	0.218	0.270	-0.192
Other respiratory	0.262	0.170	0.330	0.402	-0.313
Digestive	0.471	0.322	0.568	0.659	-0.656
Hearing Impairments	0.176	0.112	0.226	0.280	-0.200
Amputee Impairments	0.253	0.164	0.320	0.390	-0.301
Paralysed Impairments	0.571	0.404	0.673	0.761	-0.873
Orthopaedic Impairments	0.276	0.179	0.347	0.421	-0.333
$\sqrt{s^2(e)+s^2(v)}$ of HS eq.	0.884	0.820	0.909	0.902	

Table 9: Value of Illness as % of current income (UK)

Disease, Coefficients from Groot (2000), Corrected for Std. Deviation	West Workers	East Workers	West Non-Workers	East Non-Workers	Disease Coeff.
Problems with arms, legs, etc.	0.449	0.305	0.544	0.635	-0.614
Difficulty in seeing	0.205	0.131	0.262	0.322	-0.237
Difficulty in hearing	0.205	0.131	0.262	0.322	-0.237
Skin conditions, allergies	0.120	0.075	0.155	0.195	-0.132
Chest, breathing problems	0.393	0.263	0.483	0.570	-0.515
Heart, blood	0.467	0.319	0.564	0.655	-0.648
Stomach, liver, kidney	0.574	0.407	0.676	0.764	-0.88
Diabetes	0.414	0.279	0.507	0.596	-0.552
Nerves, anxiety, depression	0.488	0.336	0.587	0.678	-0.691
Alcohol, drugs	0.430	0.291	0.524	0.614	-0.58
Epilepsy	0.422	0.285	0.515	0.605	-0.566
Migraine, chronic headaches	0.233	0.150	0.295	0.361	-0.273
$\sqrt{s^2(e)+s^2(v)}$ of HS eq.	0.884	0.820	0.909	0.902	