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Income, income inequality and self-reported health in Britain 1979-2000

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Abstract. The relative income hypothesis is that an individual's health depends on the distribution of income in a reference group, as well as on the income of the individual. We use data on 231,208 individuals in Great Britain from 19 rounds of the General Household Survey between 1979 and 2000 to test alternative specifications of the hypothesis with regressions which also include individual income, gender, age, social class, education and housing tenure. In models without any relative income measures we find that there has been a decline in self assessed health over the period. There are also marked regional effects, with individuals in Wales and the North and North West of England having the worst health. People living in Scotland are as healthy as those living in the South East once their individual characteristics are allowed for. We consider four measures of relative income, national and regional reference groups, and two measures of self assessed health. The estimated effects of relative income measures are usually weaker with regional reference groups. Because there has been a decline in self reported health over the period, the effects of relative income are always weaker when time trends are included. There is little evidence for an independent effect of the Gini coefficient once time trends are allowed for. Deprivation relative to mean income and Hey-Lambert-Yitzhaki measures of relative deprivation are generally negatively associated with individual health but the effects are sensitive to the reference group and to the inclusion of time trends. Moreover a high degree of collinearity between individual income and measures of relative deprivation constructed by comparing the individual's income with the incomes within a reference group is inescapable. Estimates of the relationship between health and such relative deprivation measures are likely always to be imprecise.

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1 Introduction

There is considerable evidence that individuals with higher incomes have better health (see for example, Pritchett and Summers, 1997) but that the beneficial effects of income decline with income (see for example, Ettner, 1996). It has also been suggested that an individual's health is affected by the income of other individuals in a reference group (Wilkinson, 1996). The *relative income hypothesis* takes a variety of forms (Deaton, 2003; Wagstaff and van Doorslaer, 2000). One strand in the literature (the *income inequality hypothesis*) focuses on the overall distribution of income and suggests that an individual in a society with greater income inequality will have worse health, even if they have the same income as an individual in a more egalitarian society. Income distribution may affect individual health directly because it induces stress and anxiety or because it leads to particular patterns of public and private consumption which affect health (Lynch et al, 2000). For example societies with less equal income distributions may have worse public health services. Another strand (the *relative deprivation hypothesis*) suggests that what matters is the difference between an individual's income and the incomes of individuals in their reference group, rather than overall inequality in income distribution.

Three types of data set have been used to test the relative income hypothesis: (a) aggregate population level data on income and health; (b) individual level data on income in an area linked to population level health measures; (c) individual level data on income and health linked at individual level. Most of the empirical literature attempting to test the relative income hypothesis has used aggregate level data of type (a) and looked for a relationship between population health, mean income and measures of income inequality. The bulk of the aggregate level analyses suggest that, holding per capita income constant, population health is worse in societies with less equal income distributions (see the studies surveyed in Deaton, 2003; Judge and Paterson, 2001; Mellor and Milyo, 2001; Wagstaff and van Doorslaer, 2000). A minority of aggregate level studies find no or a positive relationship between population health and income distribution (for example Gravelle, Wildman and Sutton, 2001; Mellor and Milyo, 2001; Muller, 2002; Ross et al, 2000).

Almost all the type (a) studies are attempts to test the income inequality version of the relative income hypothesis. Such aggregate level analyses cannot test relative deprivation hypotheses as this requires measures of individuals' income relative to some reference group. Nor can they test the plausible suggestion that the effects of income inequality or of relative deprivation differ across richer and poorer individuals.

Aggregate studies also suffer from an obvious aggregation problem: in general it is impossible to test hypotheses about individual level relationships with data averaged over individuals unless the relationships are linear. If income improves health but at a decreasing rate, increases in the dispersion of income will reduce mean health, even if the health of an individual is entirely determined by their income (Rodgers, 1979; Gravelle, 1997).

Type (b) data sets arise when there are data on individual level incomes in an area but the only link to health data is at the area level. Type (b) data sets can be used to test relative deprivation versions of the relative income hypothesis. Miller (2001) used a variety of specifications of the health function with data on individual incomes within US states and state level mortality and found little or no association between income inequality and health.

Compared to the aggregate level studies there are few type (c) studies with data on health and income linked at individual level. On the whole they are less favourable to simple versions of the relative income hypothesis (Mackenbach, 2002; Osler et al, 2002; Shibuya et al, 2002; Sturm et al, 2002). Blakely, Atkinson and O'Dea (2003) used the New Zealand 1991 census and 1991-4 mortality records for 1.4 million adults aged 25 to 64. They found no association between mortality and regional Gini coefficients. Controlling for regional mean income, household income, age, ethnicity, gender, and rurality, they found no association between individual mortality and regional Gini coefficients. Osler, Christensen, Due et al, (2002) used cohort data on 21721 Copenhagen adults followed for up to 18 years (1980 to 1997). Income inequality was measured as the share of total household income accruing to the poorest 50%. After allowing for household income, household composition, and baseline smoking, drinking, physical activity and health measures, there was a weak inverse association between the risk of an IHD event and income inequality as measured at parish or municipal level. By contrast the cross-sectional analysis in Diaz-Roux, Link and Northridge (2000) found that four IHD risk factors were higher for men in US states with greater income inequality but not for women.

There have been three individual level studies using British data, all based on the British Household Panel Survey (BHPS). Weich, Lewis and Jenkins (2002) used the first, 1991, wave of the BHPS and found some evidence of a detrimental effect of income distribution on self reported health with the effect being more pronounced amongst poorer individuals. The relationship was not robust to the measure of income distribution, being strongest for the Gini coefficient. They noted that income inequality is greater in more urban regions and suggest that income inequality may be picking up some characteristic of cities.

Weich, Lewis and Jenkins (2001) looked at mental health, measured using the General Health Questionnaire, in the first wave of BHPS. Individuals with the lowest incomes had the worst mental health, but higher income individuals had worse mental health than those on moderate incomes. For individuals with low incomes, mental health problems were more common if they lived in regions with low Gini coefficients, whereas for individuals with high incomes they were more common in those living in regions with high Gini coefficients. Thus income inequality had an adverse effect on the mental health of the rich and a protective effect for the poor. Wildman and Jones (2001) also used the BHPS but used panel data methods to allow for unobserved individual heterogeneity. They found that mental health was unrelated to income but was adversely affected by subjective measures of financial well-being. The mental health of poor women was adversely affected by the Hey and Lambert (1980) relative deprivation measure but men and those on higher incomes were not affected. The implications of these UK studies is that the association between income inequality and health is sensitive to the measures of health, of income, and of income distribution. They also suggest that the association may be different for the rich and the poor.

In this paper we make a number of contributions. First, we use data from 19 rounds of the British General Household Survey (GHS) to add to the small number of individual level studies. Because the sample of individuals was different in each round of the GHS we are unable to allow for individual unobservable heterogeneity. But there are considerable compensations in using the GHS. In addition to a large sample size in each period, the data span a period (1979 from 2000) which experienced upturns and downturns in the economic cycle and varying changes in the economic fortunes of different regions within Britain and considerable changes in the degree of income inequality (Goodman and Shephard, 2002). Second, we compare four versions of the relative income hypothesis: one version of the income inequality hypothesis using the Gini coefficient and three versions of the relative deprivation hypothesis. Third, we test if the effects of relative income in these three versions differ for individuals with below and above average income. Fourth, in modeling the effect of relative deprivation on health it is not obvious a priori what population is the relevant reference group. The estimated effect of relative deprivation has been found to vary with the reference group used to construct income inequality or relative deprivation measures (Osler, Christensen, Due et al, 2002). With our data set we are able to use both national and regional reference groups in constructing our measures of income inequality and relative deprivation. Finally, we examine the sensitivity of the results to the choice of health measure by comparing a measure based on a three category general health question with a binary measure of functioning (limiting long term illness).

2 Data

2.1 General Household Survey

Data on individual health and household income were obtained from 19 annual cross-sections of the General Household Survey (GHS) for the period 1979-2000/1.[1] (There was no GHS in 1997 and 1999 and we had to drop the 1983 round since neither the income variable or the variables required to calculate it were available in the public-use dataset.) The GHS is a representative cross section survey of private households in England, Scotland and Wales, not a panel (www.statistics.gov.uk/ssd/surveys/general_household_survey.asp). The survey sample size decreased steadily throughout the period from approximately 31,000 in 1979 to 23,500 in 2000/1. Summary statistics for the sample used in the analysis are in Table 1.

The main advantage of the GHS for our purposes is the long time-period covered. Though this restricts us to variables which have been collected consistently throughout the period we are able to use two self-reported simple measure of health status, gross household income, age, gender and information on educational attainment, housing tenure and social class.

Educational information is available only for respondents aged less than 70. Self-assessed health status is asked only of respondents aged 16 and over. We therefore use only the 16-69 age group. We measure the age variable as *age in years*/100.

The measure of household income that has been collected throughout the period is gross household income, before tax and housing costs. Income has been converted to 2000 prices using the Retail Price Index (Office for National Statistics, 2003a). In all years household income has been equivalised using the Before Housing Costs McClements scale (Office for National Statistics, 2003b). For clarity of presentation, the resultant income variable is transformed so that the minimum value = 0 and the maximum value = 1.

Information on income and self-assessed health is available for 241,779 individuals (73.4% of the initial sample). We omit the 1st and 99th percentiles of the income distribution to remove zero incomes and some very large reported incomes, since these may have disproportionate effects on the estimated income-health relationship and measures of relative income. There is also missing information for some respondents on home ownership, education level and social class. The resulting sample size is 231,208 (70.2%).

[1] Each round of the GHS was initially administered within a calendar year but from 1988/89 onwards rounds have taken place within financial years.

Reference groups were created by stratifying the sample by (a) year only and (b) year and eleven areas (Scotland, Wales and 9 English regions). Measures of income inequality within reference groups and reference group mean incomes were based on all respondents with non-missing and non-outlier income information as they are most likely to be representative of the reference groups. In the region within year analyses observations are distributed across 209 strata (11 regions over 19 years). The median and inter-quartile range of the strata size are 1,028 and 791-1,256.

2.2 Health measures

We use two health measures. The first is a three-category measure of self-assessed general health status and the second is the *absence* of a chronic condition which limits the individual's daily functioning. Increases in both measures correspond to better health.

2.2.1 General health

Self-assessed general health status is derived from answers to the question "How would you rate your health in general? Good, fairly good or not good". It is a widely used measure and was, for example, part of the UK's decennial population census in 2001. Self-assessed health measures have been shown to be good predictors of subsequent mortality (Idler and Benyammi, 1997) for all socio-economic groups (Burström and Fredlund, 2000).

To increase the amount of information from the health measure we use a procedure that has been validated on good quality Canadian data (van Doorslaer and Jones, 2002). We assume that health is a continuous but unobserved variable (*h*) which lies between 0 and 1. An individual who has *h* between 0 and the critical value α_1 reports their health as "not good". One who has *h* between the critical values α_1 and α_2 reports "fairly good" health and one who has *h* between α_2 and 1 reports "good" health. If we know the critical values, we can use interval regression to estimate the most likely value of *h* for an individual given their reported health category, and their age, gender and income.

We obtain the critical values from the 1996 Health Survey for England (HSE). The HSE contains the EuroQol EQ-5D (EuroQol Group, 1990) health instrument, which asks about five dimensions of health. The EuroQoL answers from 16,047 respondents aged sixteen and over were converted to a health utility scale between 0 and 1 using a set of weights for the UK based on the Time Trade-Off technique (Dolan, 1997). The quantiles of the resulting empirical distribution of HSE health utilities were matched with the cumulative frequencies of observations for the categories of self reported health (h^s) in England in 1995 from the GHS. For example, in 1995 13.17% of the English GHS respondents reported "not good" health and 13.17% of the HSE respondents had a health score below 0.691. Hence we set the critical value α_1 equal to 0.691. Similarly we calculate $\alpha_2 = 0.848$.

Once the critical values are determined we estimate the individual level health function by interval regression using STATA 8.2 [*intreg*]. We use robust standard errors and allow for clustering of the error terms between respondents in the same region and year. The specification of the health regression varies according to the form of the relative income hypothesis.

2.2.2 Absence of limiting long standing illness (ALLI)

The GHS also contains the question "Do you have any long-standing illness, disability or infirmity? By long-standing, I mean anything that has troubled you over a period of time or that is likely to affect you over a period of time?" Those who report a longstanding illness are then asked if it limits their activities in any way. To make comparison with the results from the general health measure easier we define a binary health measure taking the value 1 if the individual does *not* report limiting longstanding illness (LLI) and 0 otherwise. We estimate the resulting individual model as a logistic regression [*logit, robust cluster(group)*]. Since the results we obtained were qualitatively very similar to those with the general health measure we do not report them here.

3 Alternative specifications of the relative income hypothesis

3.1 Income inequality

The first set of models test for an effect of income inequality as measured by the Gini coefficient G on health. The Gini is frequently used in the literature, especially in aggregate level studies. When the reference group is the national population the model is

$$h_{ijt} = \beta_0 + \beta_1 y_{ijt} + \beta_2 y_{ijt}^2 + \beta_3 y_{ijt}^3 + \beta_4 y_{ijt}^4 + \gamma_1 G_t + x_{ijt}'\delta + u_{ijt} \quad (1)$$

where h_{ijt} is the health measure for individual i in region j in year t, y_{ijt} is equivalised household income, x_{ijt}' is a vector of demographic and socio-economic individual variables. The power function of income here and in the other specifications allows for the non-linearity of the relationship between income and health.

We estimate a number of variants of (1). (a) We allow for the possibility that the effect of the Gini depends on whether the individual is "rich" (income above the reference group mean) or "poor" (income below reference group mean) by adding a term $D_{ijt}^t G_t$ where the dummy variable (D_{ijt}^t) indicates whether the individual has income below or above the national average y_t in that year ($D_{ijt}^t = 1$ if $y_{ijt} \le y_t$; = 0 otherwise). (b) We also estimate (1) and all the other specifications discussed below with the reference group being the region, so that the mean income level for defining the "poor" dummy is the mean income in region j in year t ($D_{ijt}^{jt} = 1$ if $y_{ijt} \le y_{jt}$; = 0 otherwise) and G_t is replaced by G_{jt} (and analogously in the other specifications below).

(c) Although we do not show them in (1) or in the other equations describing our models, we also allow for regional effects by the inclusion of region dummies with the South East of England as the baseline region. In models with regional reference groups we also incorporate year dummies with 1979 as the baseline year. In models with national reference groups, year dummy variables would be perfectly co-linear with variables like the national Gini coefficient which are invariant across individuals within a year. Hence national reference group models do not contain year dummy variables. However we do separately examine the relationship between national Ginis and the year effects from a model estimated without national Ginis and estimate a model where the time trend is modeled as a linear effect.

(d) It is plausible that reported health is determined by previous values of income and relative income (Benzeval and Judge, 2001). Since the GHS is a cross section and contains current data on individuals we cannot allow for possible lagged effects of socioeconomic factors on health. However we can calculate measures of income distribution for previous years and we estimate specifications with the current year Gini plus the Ginis for the previous five years.

(e) Osler, Christensen, Due et al (2002) found some evidence that the effect of income distribution was non-linear. We therefore also consider specifications with quadratic and cubic functions of the Gini.

3.2 Deprivation relative to mean income

The second variation of the relative income hypothesis is that individuals have worse health the higher the mean income of their reference group.[2] To save notational clutter we write the model in terms of the conditional expected value of the individual's health, suppress the identifying subscripts and collect the powers of income and socio-economic variables and any year and region effects into the constant term:

$$h = \beta_0 + \beta_1 y + \lambda_1 (y - \bar{z}) + \lambda_2 D(y - \bar{z}) \qquad (2)$$

where h is now the conditional expected value of individual health, y is individual income, $\bar{z}$ is the mean income of the reference group and $D = 1$ if $y \le \bar{z}$ and 0 otherwise. An increase the mean income reduces the health of someone above the mean whose income is not changed if $\lambda_1 > 0$. An increase in mean income reduces the health of a person below the mean whose income has not changed if $\lambda_1 + \lambda_2 > 0$. Mean income has a greater impact on the poor if $\lambda_2 > 0$.[3]

The measure of relative deprivation in (2) is additive since $y - \bar{z}$ is unaffected by adding a constant to the income of the individual and all those in her reference group. Thus an individual with an income of £10,000 whose reference group has a mean income of £20,000 faces the same relative deprivation as in individual with an income of £40,000 whose reference group has a mean income of £50,000. We also investigate specifications in which health depends on the proportionate difference $y/\bar{z}$ between individual income and the reference group mean income so that $y/\bar{z}$ replaces $y - \bar{z}$ in (2).

3.3 Relative deprivation

The use of mean income as the comparator implies that an individual with an income of 2 units would feel as deprived in a society with an income distribution (2,2,3,3,3,3) as in an economy with distribution (1,2,2,2,2,7). Measures of relative deprivation which are sensitive to the whole distribution of income rather than its mean, and which allow for the possibility that health is differentially affected by the income distribution above and below the individual's income, can be derived as follows (Yitzhaki, 1979; Hey and Lambert, 1980; Deaton, 2003).

Define the extent of *additive relative deprivation* for an individual with income y with respect to another individual in her reference group with income z as

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[2] There is an obvious link with the literature on life and job satisfaction where investigators have found that satisfaction of individuals is lower the higher the income of a reference group (Clark and Oswald, 1996; Ferrer-i-Carboneli, 2002).

[3] We also specified the model as $h = \beta_0 + \theta_1 y + \theta_2 Dy + \theta_3 \bar{z} + \theta_4 D\bar{z}$, where $\theta_1 = \beta_1 + \lambda_1$, $\theta_2 = \lambda_2$, $\theta_4 = -\lambda_2$ and found that we could not reject the null that the two estimates of the differential effect on the poor (λ_2) were equal: $\hat{\theta}_2 + \hat{\theta}_4 = 0$.

$$a_1(y;z) = z - y \quad \text{if} \quad z \geq y$$
$$= 0 \quad \text{if} \quad z < y \tag{3}$$

The total additive relative deprivation experienced by an individual with income y with respect to all richer individuals in the reference group is

$$A_1(y) = \int_y^{\infty} a_1(y;z) f(z)dz = \int_y^{\infty} (z-y) f(z)dz \tag{4}$$

which is decreasing and convex in the individual's income:

$$A_1'(y) = -[1 - F(y)] < 0, A_1'' = f(y) > 0 \tag{5}$$

where $f(z)$ is the density (relative frequency) of income in the reference group, and $F(y)$ is the cumulative frequency (proportion of the reference group population with an income which is less than or no more than y).

It is also possible that an individual may care about being richer than other individuals. Define her *additive relative affluence* (relative satisfaction in Yitzhaki (1979)) with respect to an individual with income z as

$$a_2(y;z) = y - z \quad \text{if} \quad y \geq z$$
$$= 0 \quad \text{if} \quad y < z \tag{6}$$

and her total additive relative affluence as

$$A_2(y) = \int_0^{y} a_2(y;z) f(z)dz = -\int_0^{y} (z-y) f(z)dz = A_1(y) - (\bar{z} - y) \tag{7}$$

which is increasing and convex in own income.

The relative deprivation measures also have the advantage of being individual rather than reference group specific, so we are able to include year effects even when we use national reference groups.

We allow both additive relative deprivation and additive relative affluence to affect health:

$$h = \beta_0 + \beta_1 y + \psi_1 A_1(y) + \psi_2 A_2(y) \tag{8}$$

So that health is reduced by relative deprivation if $\psi_1 < 0$ and increased by relative affluence if $\psi_2 > 0$. Using (7) we see that (8) nests the case in which only income relative to the mean has a detrimental effect on health ($\psi_1 + \psi_2 = 0$, $\psi_1 < 0$).

Alternatively, relative deprivation and affluence may be measured so that equiproportional changes in income have no effect on how relatively deprived the individual feels. Replacing $a_1(y,z)$ and $a_2(y,z)$ in the definitions of additive relative deprivation and affluence by $a_1(y,z)/\bar{z}$ and $a_2(y,z)/\bar{z}$ gives proportional relative deprivation and affluence as $R_1(y) = A_1(y)/\bar{z}$ and $R_2(y) = A_2(y)/\bar{z}$ which are dimensionless and lie in [0,1]. We estimate specifications with both proportional relative deprivation and affluence

$$h = \beta_0 + \beta_1 y + \phi_1 R_1(y) + \phi_2 R_2(y) \tag{9}$$

which also nests the special case in which only income proportional to mean affects health ($\phi_1 < 0, \phi_1 + \phi_2 = 0$).

4 Results

4.1 Models with no relative income effects

Table 2 shows the results from regressions of self-assessed health on age, sex, region and year (first model) and all the variables except measures of relative income or deprivation (second model). The coefficients on these variables are very similar to those from models which include measures of relative income. Over the age range for our sample (16 to 69) health is decreasing, very nearly linearly with age. Individuals living in rented accommodation are less healthy and there are clear gradients of health with education and social class: the better educated and those in higher social classes are more healthy. Income is standardised to lie between 0 and 1. Over the income range (0,0.83) health is increasing income, steeply up to 0.25 and then more slowly. Over the income range (0.83, 1.00) health decreases with income although only 67 (0.03%) of the sample have incomes in this range.

There are significant area effects on health (South East England is the omitted area). The three healthiest areas are East Anglia, South East England and Scotland, and the three least healthy are North West England, Yorkshire and Humberside, and Wales. The fact that individuals living in Scotland are relatively healthy may appear surprising but remember that these are effects of area after allowing for a wide range of individual covariates. When we control only for age and gender (first model), the Scottish effect is –0.011 (t=-13.1). The worse health of the Scottish population is due to the socio-economic characteristics of people who live in Scotland, not to the fact that they live in Scotland.

The results for absence of limiting longstanding illness are qualitatively similar and not shown. The year coefficients for both health measures suggest a secular, though not monotonic, decline in health over the period. See Figure 1.

4.2 Relative income as income inequality

Table 3 shows the effects of overall income inequality, as measured by the Gini, for various specifications of the income inequality version of the relative income model. All the models include regional dummies, except where stated. When the reference group is the national population and we do not included a time trend, the coefficients on the Gini are negative and highly significant, whether or not we include regional dummies. When the national Gini is allowed to have a different effect for individuals with above and below mean income, its effect is significantly more negative for the poor. With the lagged models the effect of the two most recent years national Ginis are negative for both measures and the effect of a given increase in the national Gini sustained over five years is also negative. The quadratic and cubic models (results not shown) also suggest that an increase in the national Gini reduces general health.

The results for the national reference group are greatly affected by the inclusion of a linear time trend: the coefficient on national Gini becomes positive. The reason for the sensitivity of the results for the national Gini to inclusion of a time trend, as Table 2 shows, is that there is a downward trend in self assessed health when no relative income terms are included in the health equation. The national (and regional) Ginis have a strong upward trend over the period. Hence in the national Gini model with no time trend, where we cannot include year dummies because of perfect colinearity, the Gini picks up the downward health trend. Including a linear time trend leaves the national Gini to explain variations around the trend and its coefficient becomes positive.

Figure 2 is a scatter plot of the year effects from the second general health model in Table 2 against the year Ginis. The national Gini is highly negatively correlated ($R^2 = 0.63$) with the unexplained year effects. The significance of the national Gini in the health models is not necessarily due to a causal effect. Any national level variable which is trended over time would also have a significant effect in the health model. Moreover, when two time series are trended the correlation between them can be entirely spurious. Figure 3 plots the first differences of the year effects against the first differences of the year Gini. The R^2 is 0.01.

The results with regional year reference groups are generally very different from those with national year reference groups and provide little support for the income inequality version of the relative income hypothesis. When year dummies are included, the effects of the regional-year Gini are positive for both health measures, both for individuals with above and below average income. The coefficients for the quadratic and cubic models (not shown) and lagged models are generally insignificant.

Dropping the year effects from the models with regional-year Ginis leads to the coefficient on the Gini becoming negative and significant, irrespective of whether regional effects are also included. Hence for models with regional-year or year Ginis as the measure of relative income the estimated effect of the Gini depends crucially on whether the models include variables (a set of year dummies or a time trend) which capture the downward trend in self reported health. In models where we include both Ginis and such variables, the coefficient on the Gini suggests no or even a positive effect on health.

4.3 Deprivation relative to mean income

In the first two models in Table 4 relative income is defined as the difference between the individual's income and the mean of a reference group. Referring back to the health equation (2), relative deprivation reduces health if λ_1 is positive (so decreases in income relative to the mean reduce health). With the national reference group and no year dummies, the results support the relative deprivation hypothesis with health declining as income relative to the mean decreases, with larger negative effects for individuals below mean income. Since mean income increased over the period, including a time trend in the additive deprivation case has a considerable impact on the estimated effects of the difference from the national mean. The effect of increased income relative to the mean is still positive but both its magnitude and significance are reduced. When we include year dummies in the proportional version of the model, increases in income relative to the mean have a negative effect on health.

In models using regional reference groups the inclusion of year dummies also has a marked effect. In models with no year dummies increases in income relative to the mean have a strong positive effect on health. With year dummies the effect is still positive but it is considerably smaller and sometimes insignificant.

4.4 Relative deprivation

Table 5 reports the results with the Yitzhaki-Hey-Lambert measures of relative deprivation and affluence. For the models where we enter only the additive relative deprivation measure (A_1) we report results with and without year effects. When there are no year effects the coefficient on A_1 is negative and has large t statistics. With year effects the coefficients are greatly reduced in size and significance and become positive and insignificant in the regional reference group cases. When we enter only the proportional relative deprivation measure R_1 the use of year effects again greatly reduces the magnitude and significance of the coefficients on R_1 though the coefficients are negative and remain significant even for the regional reference groups.

When we attempt to test for the effects of both additive relative deprivation and affluence, the effect of additive relative affluence is positive and significant but the effect of additive relative deprivation is insignificant with regional reference groups. With national reference groups, additive relative deprivation has significant negative effect and the effect of additive relative affluence is small and insignificant. With both reference groups we reject the null hypothesis that only income relative to the mean affects health.

With regional reference groups proportional relative deprivation has a significant negative effect and relative affluence a significant positive effect. But with a national reference group whilst proportional relative deprivation has a significant negative coefficient, proportional relative affluence has a significant negative effect. We reject the null hypothesis that only income proportional to the mean affects health for both reference groups.

We attempted to test whether the reference group is regional or national by including relative deprivation defined with respect to both groups in the models for additive and proportional relative deprivation. For both additive and proportional relative deprivation we find that the effect of deprivation relative to the region improves health and deprivation relative to the nation worsens it. However, models with relative deprivation measures for both national and regional reference groups suffer from severe multi-collinearity problems. The R^2 from regressions of the regional reference group measures on the national reference group measures (and vice versa) plus all the individual covariates, year and region dummies ranged between 0.965 and 0.9962 and variance inflation factors between 28.9 and 263.2.

One difficulty with attempting to test for relative deprivation versions of the relative income hypothesis is that an individual's relative deprivation is a decreasing function of their income. But since their income also plausibly has a direct effect on their health it is then difficult to disentangle the two effects and to test for a relative income effect. The relative deprivation measures are highly correlated with income so that any regression equation which includes them both is likely to suffer from severe multi-collinearity. We regressed the relative deprivation measures on all the individual variables, year dummies and regional dummies. The R^2 for the four (regional, year, additive, proportional) regressions ranged between 0.9521 and 0.9925 and the variance inflation factors ranged between 20.9 and 133.3. There is more independent variation in the additive compared to the proportional measures, and in the regional compared to the year measures.

5 Discussion

The relative income hypothesis has received a substantial amount of attention. Testing for the effects of relative income is best undertaken with individual-level data, yet there have been few published studies using UK data and all have been based on the same data set. In this paper we have used data on over 230,000 individuals sampled over a period of considerable changes in economic fortunes. We find no support for the effect of income distribution (measured by the Gini coefficient) but some weak evidence that relative deprivation has a significant effect on health.

With a large dataset we have been able to also explore a number of methodological issues. We considered four measures of relative income for two reference groups defined by the year of observation and by the region and year of observation. Our results suggest that income relative to the national reference group has a more significant effect on individual health. Such a funding poses considerable estimation problems for some of the versions of the relative income hypothesis. If the reference group is a national one and the measure of relative income is the same for all individuals (such as the Gini) then it is very difficult to distinguish between the effects of relative income and secular trends in health. One should not attempt to test for the effects of the Gini, for example, by examining correlations between Ginis and year or regional effects estimated from other models. Since the number of observations is only equal to the number of years of observation if the reference group is national, it is difficult to envisage a sufficiently long dataset that would enable us to distinguish between the effects of the Gini and other variables that may explain the secular trend in health.

The situation is improved if we consider other measures of relative income that are not the same for all individuals within the reference group. In the case of the Hey-Lambert-Yitzhaki measures of relative deprivation, for example, we can allow flexibly for secular trends in health even with national reference groups. However, since these relative deprivation measures are a decreasing function of the individual's income, and income may exert a direct influence on health, the variables will be highly collinear. Distinguishing between income itself and relative income remains a substantive problem even in a dataset as large as this one.

We therefore conclude that it is difficult to test relative income models with data sets that contain no direct information on reference groups and relative income. One solution might be to ask individuals directly if they feel themselves to be relatively deprived but construction of such questions may be fraught with problems.

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Table 1. Summary statistics

Variable	Cases	Mean	St.Dev.	Min	Max
Age (years/100)	231208	0.4146	0.1485	0.1700	0.6900
Female	231208	0.5248	-	0	1
NLLSI	231208	0.8067	-	0	1
'Fairly Good' self-assessed health	231208	0.2539	-	0	1
'Not Good' self-assessed health	231208	0.1062	-	0	1
Equivalised income y_{ijt}	231208	0.1596	0.0996	0.0000	1.0000
Annual mean income y_t	19	0.1444	0.0195	0.1172	0.1785
Annual Gini coefficient G_t	19	0.3290	0.0359	0.2687	0.4051
Annual additive relative deprivation A_1	231208	0.0424	0.0339	0.0000	0.1785
Annual additive relative affluence A_2	231208	0.0576	0.0719	0.0000	0.8215
Annual proportional relative deprivation R_1	231208	0.2891	0.2201	0.0000	1.0000
Annual proportional relative affluence R_2	231208	0.3936	0.4693	0.0000	4.6011
Annual income ratio y_{ijt}/y_t	231208	1.1045	0.6463	0.0000	5.6011
Regional year mean income y_{jt}	209	0.1445	0.0258	0.1033	0.2146
Regional year Gini coefficient G_{jt}	209	0.3228	0.0377	0.2516	0.4501
Regional year additive relative deprivation A_1	231208	0.0414	0.0343	0.0000	0.2144
Regional year additive relative affluence A_2	231208	0.0565	0.0702	0.0000	0.8541
Regional year proportional relative deprivation R_1	231208	0.2827	0.2188	0.0000	1.0000
Regional year proportional relative affluence R_2	231208	0.3861	0.4558	0.0000	5.8529
Regional year income ratio y_{ijt}/y_{jt}	231208	1.1034	0.6314	0.0000	6.8529
Rents home	231208	0.3420	-	0	1
High formal qualifications	231208	0.0993	-	0	1
Medium formal qualifications	231208	0.2791	-	0	1
Low formal qualifications	231208	0.2035	-	0	1
Foreign/other qualifications	231208	0.0289	-	0	1
No formal qualifications	231208	0.3893	-	0	1
Social class I	231208	0.0380	-	0	1
Social class II	231208	0.1896	-	0	1
Social class IIINM	231208	0.2691	-	0	1
Social class IIIM	231208	0.2151	-	0	1
Social class IV	231208	0.1922	-	0	1
Social class V	231208	0.0665	-	0	1
Social class unclass.	231208	0.0294	-	0	1

Table 2. Determinants of self assessed health: no relative income effects

	Self assessed health		Self assessed health	
	Coeff.	z	Coeff.	z
Rents home			-0.019	-34.4
Medium formal qualifications			-0.007	-8.7
Low formal qualifications			-0.010	-12.2
Foreign/other qualifications			-0.013	-8.5
No formal qualifications			-0.021	-23.9
Social class II			-0.002	-2.2
Social class IIINM			-0.004	-3.3
Social class IIIM			-0.010	-8.9
Social class IV			-0.011	-9.3
Social class V			-0.012	-9.6
Social class unclassified.			-0.007	-4.1
North of England	-0.021	-14.1	-0.009	-6.5
Yorkshire/Humberside	-0.016	-16.7	-0.008	-7.9
North West England	-0.017	-22.4	-0.010	-13.9
East Midlands	-0.010	-12.6	-0.004	-4.6
West Midlands	-0.014	-19.7	-0.005	-7.0
East Anglia	-0.001	-0.8	0.003	2.7
London	-0.010	-10.6	-0.006	-6.0
South West England	0.000	-0.3	0.004	4.3
Wales	-0.016	-16.2	-0.007	-7.3
Scotland	-0.011	-13.1	-0.001	-0.6
1980	-0.004	-3.3	-0.004	-3.4
1981	0.003	3.0	0.003	2.9
1982	0.004	3.8	0.003	2.5
1984	0.006	3.4	0.002	1.7
1985	0.005	4.3	0.001	0.4
1986	0.003	2.6	-0.004	-3.2
1987	-0.001	-1.1	-0.008	-7.9
1988/89	-0.001	-0.6	-0.009	-7.5
1989/90	0.004	3.3	-0.006	-4.1
1990/91	0.000	0.1	-0.010	-7.6
1991/92	0.005	3.8	-0.005	-3.3
1992/93	0.005	3.6	-0.006	-4.7
1993/94	0.002	1.6	-0.008	-7.7
1994/95	0.001	0.4	-0.010	-5.3
1995/96	-0.001	-1.1	-0.012	-12.2
1996/97	-0.007	-4.4	-0.018	-11.6
1998/99	-0.002	-1.7	-0.016	-11.3
2000/01	-0.002	-1.4	-0.016	-11.4
Equivalised income			0.466	15.6
Equivalised income^2			-1.437	-9.2
Equivalised income^3			1.921	6.4
Equivalised income^4			-0.897	-4.9
Constant term	0.844	123.6	0.839	114.9
Sigma	0.092	227.0	0.089	246.1
Log-Likelihood (Initial)	-242506.5		-242506.5	
Log-Likelihood (Model)	-232369.4		-226699.3	
Pseudo-R^2	0.0418		0.0652	
Observations	231,208		231,208	

Both models also include gender, a cubic in age and gender*age power interactions

Table 3. Tests of the income inequality hypothesis

	Regional ref group				National ref group			
	Year effects	Coef.	t	Log likelihood	Year effects	Coef.	t	Log likelihood
G	No	-0.124	-11.1	-226899.2	No	-0.137	-13.2	-226861.4
G	Yes	0.079	3.6	-226692.9	Trend	0.093	2.8	-226805.3
G no regional effects	No	-0.128	-9.3	-227095.6	No	-0.136	-9.0	-227094.7
G no regional effects	Yes	-0.066	-2.5	-226924.6	Trend	0.089	1.9	-227041.0
G	Yes	0.081	3.6	-226687.9	No	-0.130	-11.8	-226858.7
G*D		-0.008	-2.9			-0.006	-2.1	
G	Yes	0.081	1.6	-93415.9	No	-0.500	-3.0	-93419.2
G-1		-0.045	-0.9			-1.109	-3.4	
G-2		0.015	0.3			0.502	1.8	
G-3		0.048	1.0			1.017	5.9	
G-4		0.022	0.4			1.699	4.5	
G-5		-0.042	-0.9			-1.918	-6.6	

G: Gini. G-t: Gini at lag t years. G*D: effect of Gini on individuals with income below mean.

Table 4. Tests of the relative deprivation hypothesis: mean income version

	Reg ref group				National ref group			
Additive deprivation	Year effects	Coef	t	Log likelihood	Year effects	Coef	t	Log likelihood
Difference from mean y (λ_1)	N	0.256	13.2	-226827.4	N	0.278	15.4	-226809.3
Difference from mean y (λ_1)	Y	0.063	1.7	-226697.4	Trend	0.160	3.1	-226802.3
Differential effects	Y			-226690.9	N			-226749.5
Effect on rich (λ_1)		0.037	1.0			0.146	7.3	
Additional effect on poor (λ_2)		0.065	2.4			0.239	8.7	
Proportional deprivation								
y/Mean y	N	0.026	14.5	-226899.9	N	0.027	13.1	-226926.9
y/Mean y	Y	0.005	2.3	-226690.9	Y	-0.014	-4.0	-226687.5
Differential effects	Y			-226696.0	N			-226897.6
Effect on rich (λ_1)		0.005	2.2			0.026	14.4	
Additional effect on poor (λ_2)		0.000	-0.3			0.002	1.9	

All models include area effects and individual characteristics

Table 5. Tests of the relative deprivation hypothesis: additive and proportional relative deprivation versions

	Reg ref group				Nat ref group			
Additive deprivation	Year effects	Coef	t	Log likelihood	Year effects	Coef	t	Log likelihood
Relative deprivation (A_1)	N	-0.278	-12.0	-226878.6	N	-0.348	-15.5	-226790.9
Relative deprivation (A_1)	Y	0.004	0.1	-226699.3	Y	-0.308	-5.9	-226675.5
Relative deprivation and affluence:	Y			-226696.6	Time trend			-226785.1
Effect of relative deprivation ψ_1		-0.046	-1.1			-0.242	-4.2	
Effect of relative affluence ψ_2 .		0.085	2.1			-0.016	-0.3	
H^o: only income proportional to mean affects health $\psi_1 + \psi_2 = 0$		$\chi^2(1)=0.99$	p=0.319			$\chi^2(1)=23.45$	P<0.0001	
Proportional deprivation								
Relative deprivation (R_1)	N	-0.074	-14.3	-226838.5	N	-0.080	-15.0	-226800.3
Relative deprivation (R_1)	Y	-0.026	-2.6	-226694.2	Y	-0.079	-6.0	-226673.3
Relative deprivation and affluence:	Y			-226689.0	Y			-226669.5
Effect of relative deprivation ψ_1		-0.037	-3.4			-0.060	-3.5	
Effect of relative affluence ψ_2 .		0.006	2.8			-0.008	-2.2	
H^o: only income proportional to mean affects health $\psi_1 + \psi_2 = 0$		$\chi^2(1)=9.42$	p=0.0022			$\chi^2(1)=21.61$	P<0.0001	
	Regional and national reference groups							
Additive dep both ref groups	Y			-226665.6				
Regional reference group A_1		0.145	3.6					
National reference A_1		-0.431	-7.7					
Proportional dep both ref groups	Y			-226670.0				
Regional reference group R_1		0.029	2.2					
National reference R_1		-0.106	-6.0					

All models include area effects and individual characteristics.

Figure 1. Year effects from models with no relative income effects

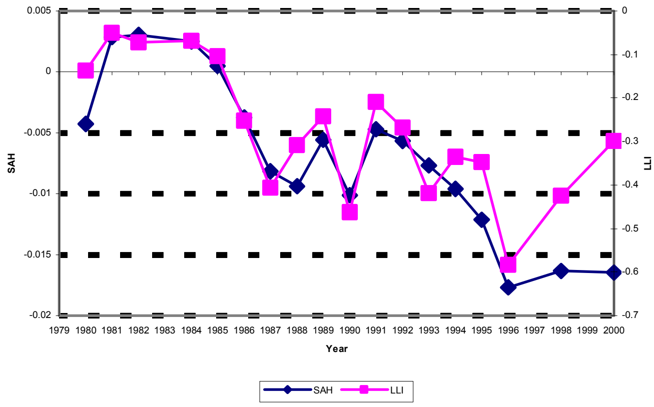

Figure 2. SAH year effects and year Ginis.

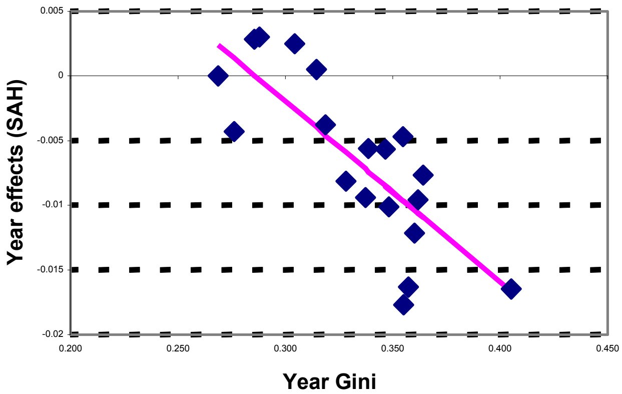

Figure 3. SAH year effects and year Ginis first differences

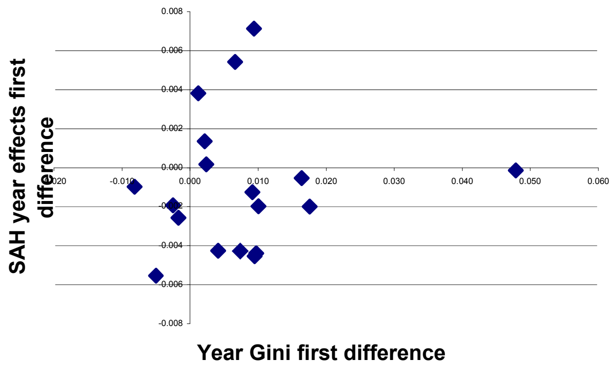

Figure 4. SAH Region-Year effects and Ginis

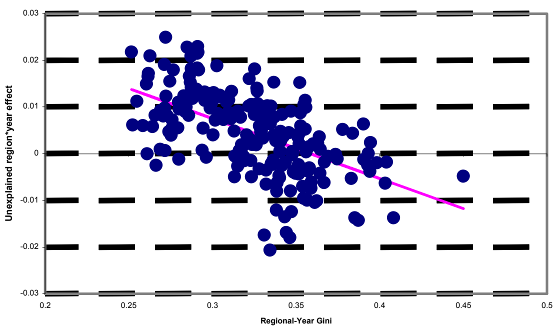

Figure 5. SAH Region Effects and mean region Ginis