The application of the relative distributions method to investigate inequalities – the case of psychological well-being and happiness

Jing Shen[1] and John Wildman[1, 2]
[1]Institute of Health and Society, Newcastle University, UK
[2]Economics, Business School, Newcastle University, UK

Corresponding author: jing.shen@ncl.ac.uk

Abstract

Introduction: This paper uses the relative distributions (RD) method to examine inequalities and polarisation in psychological well-being. The method has two advantages, i) it allows consideration of the whole distribution; and ii) the scale invariance property means that if happiness is a monotonic transformation of psychological well-being, conclusions about inequalities in happiness can be drawn. Currently, there is a focus on the importance of happiness as a measure of a country's performance. Understanding inequalities in happiness is vital if this is to become a policy tool.

Method and data: We examine the entire distribution of psychological well-being in a non-parametric fashion using RDs. RDs can distinguish between distributional changes due to median shift and shape shift and have the property of scale invariance. We use data from 1999 and 2009 Health Survey for England, which contain the General Health Questionnaire (GHQ). Relative distributions of the GHQ are performed for the year 1999 and 2009 to look at the distributional changes over a decade. Gender is examined separately.

Results and conclusions: The change in the shape of the distribution between 1999 and 2009 is the main cause of the differences in the two distributions for the entire sample and male-only sample. For the female-only sample, a shift in the location (median) of the distribution is also observed. Women typically have worse psychological well-being than men, as shown by the greater concentration of females in the upper tail of the GHQ distribution. Over the decade, women's GHQ scores have shifted downwards displaying the same median as men in the distribution of psychological well-being. Extending these results to happiness suggests that happiness has become less polarised, suggesting people are moving from the two extremes of most happy and least happy to somewhere in the middle. However, inequality in happiness has increased at the least happy end of the distribution, highlighting the importance of targeting specific group of people. Further applications of the RDs method will examine inequality in the outcome distribution conditional on socioeconomic factors, which will

provide greater insight into the complex relationships between socioeconomic factors and the subject of interest.

Key words: Inequality, Relative distributions, Happiness, Health Survey for England, Polarisation, Psychological well-being

Introduction

Inequality in health has been a widely studied topic in health economics; however, various measures of health inequality are not without criticism. The main concern of commonly used inequality measures is that they are mean-based, which is a potentially poor descriptor of the entire distribution. As a result, important information at the tails of the distribution is overlooked. Many studies of inequality also rely on parametric estimations that are based on assumptions of some underlying functional form, which may not provide robust results. The drawbacks of conventional inequality measures affect their ability to inform research and policy. In this paper, we propose an innovative method – the relative distributions method, which allows the examination of the entire distribution in a non-parametric fashion. The properties of this method also allow us to examine the distribution of correlated but different concepts without the need to measure or distinguish them. In this paper we use the example of psychological well-being.

Psychological well-being has often been used interchangeably with the terms mental health or psychological health in many studies (Shields and Price, 2001, Thomas, Benzeval and Stansfeld, 2005, Parker and Lee, 2007, Collings, 2012). The reason why psychological well-being has been often linked to mental health is self-evident. Mental health is recognised to be inseparably and positively associated with physical health for achieving a more complete state of wellness and it has already been well established that poor mental health is a direct cause of mortality and morbidity (WHO, 2008). In industrialised countries, over 40 percent of the total disease burden is now related to mental disorders (Melchior, 2007). In the UK a recent document from the Department of Health reports that mental ill health has become the single largest cause of disability, contributing up to 23% of the total burden, compared to 16% each for cancer and cardiovascular disease (Department of Health, 2011). Similar to that of physical health, there is also sufficient evidence (Fryers, 2003, Mangalore et al, 2007, Wildman, 2003, Hauck and Rice, 2004, Marín-León et al, 2007, Dalgard, 2008) suggesting the existence of inequalities in mental health within and beyond the UK. Similarly a growing

number of studies on inequalities in psychological well-being are also emerging (Skodova, et al 2009, Stefan, et al, 2006, Jones and Nicolas, 2004, Nishi, et al, 2004).

Psychological well-being has also been further linked to happiness in some studies (De Voe and Pfeffer, 2009, Clark and Oswald, 2002, Gardner and Oswald, 2002, 2006a, 2006b, and Proto, Sgroi and Oswald, 2012) through the use of the General Health Questionnaire (GHQ) available in many household surveys. GHQ is a self-administered screening test aimed at identifying minor psychiatric disorder and has been used in many studies to measure mental health (Schmitz, 1999, Werneke, et al., 2000, Weich et al, 2001, Marín-León et al, 2007, Verhaak, et al, 2005, and Thomas, Benzeval, and Stansfeld, 2005) or psychological well-being (Korten and Henderson, 2000, Shields, 2005, Kawada, et al, 2011). Using GHQ to measure any of the terms is subject to a strong assumption of an underlying utility function.

Especially with the recent call for measuring happiness as the Government is shifting its emphasis from GDP to happiness, understanding inequalities in happiness is vital if this is to become a policy tool. Happiness is difficult to measure and the Office for National Statistics is yet to come up with some credible and robust measure of happiness or well-being of the nation (ONS, 2011). The lack of a credible and robust measure of happiness means it is also difficult to study inequality in happiness using conventional methods.

The method adopted in this paper allows us to investigate the distributions of psychological well-being or happiness without having to assume a functional form from the GHQ indicator to the concept of interest. This holds as long as these terms are monotonically correlated, so any relative distribution results of GHQ can be readily translated into implications for happiness. The relationship between happiness and psychological health is well documented. Michalos (1991) has found that people with low levels of anxiety and high levels of physical health are more likely to be happy. Drawing data on 15,000 randomly sampled individuals from 16 countries, it was found that happier nations report fewer blood-pressure problems and mental distress (Blanchflower and Oswald, 2007).

The paper will demonstrate the relative distributions method using data from the Health Survey for England (HSE), where a short form of GHQ – the GHQ-12 is reported. The relative distributions of GHQ between the 1999 and 2009 surveys are presented as an

empirical example to provide insight into inequality and polarisation in psychological well-being and happiness.

The relative distributions method

The relative distributions method is described in Handcock and Morris (1999). Consider a (health) variable observed for two groups: Y_0 observed for the reference population and the same variable Y observed for the comparison population, and the latter is typically the measurement for a separate group or the same group in a later time period. The cumulative distribution function (CDF) of the outcome attribute is denoted by $F_0(Y_0)$ for the reference group and $F(Y)$ for the comparison group. Representing the differences in distributions of the outcome attribute between the reference and comparison groups, the relative distribution is defined as the distribution of the random variable R, where R = $F_0(Y)$, is the grade transformation of Y to Y_0. R indicates the percentile position of Y if it were placed in the distribution of Y_0, in other words, the relative rank of Y compared to Y_0. A point on the relative CDF is then given by the proportion of the comparison distribution that falls below the *rth* percentile point in the reference distribution consistent with a given value of Y.

The CDF of *R* is defined as:

$$G(r) = F(F^{-1}(r)) \qquad 0 \le r \le 1,$$

Where r represents the proportion of values and $F^{-1}(r) = \inf_y \{y \mid F_0(y) \ge r\}$ is the quantile function of F_0. The probability density function (PDF) of *R* is obtained from the derivative of *G*(r) with respect to r as:

$$g(r) = \frac{f\left(F_0^{-1}(r)\right)}{f_0\left(F_0^{-1}(r)\right)} \qquad 0 \le r \le 1,$$

$g(r)$ is also called the relative density and can be interpreted as a density ratio. If we express $Q_0(r)$ using the reference measurement scale *y*, with y_r denoting the *rth* quantile of *R*, then $y_r = Q_0(r)$. The relative PDF can be written as:

$$g(r) = \frac{f(y_r)}{f_0(y_r)} \qquad\qquad y_r = Q_0(r) \geq 0$$

The relative distributions method has a number of advantages over traditional measures of inequality. In addition to being able to compares the entire distribution, the method also has two key properties – scale invariant and maximal invariant (Handcock and Morris, 1999). The former ensures that the relative distributions are invariant to *all monotonic* transformations of the original measurement scale, which traditional inequality measures often do not satisfy. For example, the Lorenz curve (and associated summary measures) is multiplicatively scale invariant, that is, two distributions will have the same Lorenz curves if, and only if, they differ by a simple multiplicative constant. By contrast, relative distributions of the raw attribute, the log-attribute, or any other monotonic transformation of the attribute are equivalent, so that the results are independent from any monotone transformations of the outcome variable. With this feature, the relative distributions method makes less restrictive assumptions about the underlying utility functions in the inequality context, requiring only that they be monotonic. The property of maximal invariant ensures that any comparisons with the scale invariant property obtained from the relative distributions generate the strongest conclusions. The overall relative distributions can be decomposed into changes due to the location (or median) shift of the comparison distribution and the shape shift of the comparison distribution. This is achieved by constructing a hypothetical distribution with the same location distribution as the comparison group and the same shape as the reference group. The relative distribution between the comparison group and the reference group is the multiplicative product of the density ratios for the location difference and the shape difference.

Summary statistics including entropy and polarisation can also be obtained. Entropy indicates the dispersion of the relative distribution and is based on the Kullback–Leibler divergence measure:

$$D(F;F_0) = \int_{-\infty}^{\infty} \left(\frac{f(x)}{f_0(x)}\right) dF(x) = \int_0^1 \log(g(r))g(r)dr$$

$D(F;F_0)$ can be expressed purely in terms of the relative density without separate reference to the underlying distributions.

The polarisation index measures location-adjusted relative density in the centre or tails of the distribution, which is analogous to the difference in Gini coefficients in measuring inter-distributional inequality (Handcock and Morris, 1999). The median relative polarisation (MRP) of Y relative to Y_0 is defined as:

$$MRP(F;F_0) = 4\int_0^1 \left| r - \frac{1}{2} \right| g_0^A(x) dr - 1$$

and it is additively decomposable allowing us to distinguish the contributions made by polarizations occurring because of movements towards the lower or the upper tail. The lower and upper relative polarization indices (LRP and URP) are defined as:

$$LRP(F;F_0) = 8\int_0^{\frac{1}{2}} \left| r - \frac{1}{2} \right| g_o^A(x) dr - 1$$

$$URP(F;F_0) = 8\int_{\frac{1}{2}}^1 \left| r - \frac{1}{2} \right| g_0^A(x) dr - 1$$

respectively.

An empirical example

Data

The study uses the Health Survey for England (HSE), which is an annual cross sectional survey designed to provide regular information on various aspects of the nation's health. The HSE contains a short form of the GHQ – the GHQ-12. Each of the 12 GHQ questions has four options. A full list of the GHQ-12 questions can be found in the Appendix. The standard GHQ scoring system (Goldberg and Williams, 1991) is used, which codes the first two options as 0 and codes the last two options as 1. The total GHQ score is an addition of responses to each of the 12 questions, so that the total GHQ score ranges from 0 to 12. A total score of 0 indicates no sign of psychiatric issue while a total score of 12 represents the worst status of

psychological well-being – the higher GHQ score the worse psychological well-being. This scoring method is most widely used and reported to produce the least measurement error although discriminatory power is sacrificed (Hankins, 2008). In this study, we choose the year 1999 and 2009 to demonstrate the method and investigate the inequality in psychological health among the English population in a decade.

Relative distributions are examined between 1999 and 2009 for the entire sample, samples with GHQ truncated at 0 and GHQ truncated at 2. Men and women are examined separately. The distribution of GHQ is highly skewed as about half of the population have GHQ score of 0. Truncating GHQ at 0 (excluding observations with GHQ of 0) can better understand the distribution of the population with some sign of psychological issues, whereas truncating GHQ at 2 (excluding observations with GHQ of 0, 1 and 2) may be more informative to understand the population with psychiatric problem. The cut-off point 2/3 is chosen because the literature has suggested 2/3 to be the optimal threshold for screening psychiatric morbidity (see for example: Bashir et al. 1996; Jacob et al. 1997; Plummer, et al, 2000; Hoeymans, et al, 2004) with a sensitivity of 96.7% and a specificity of 90% (Jacob, Bhugra and Mann, 1997).

Results

Due to the space limitation, we only present the relative distributions on samples truncated at GHQ score of 0, which provide a great insight into the advantages of the method as well as the distributional changes of psychological well-being and happiness over the 10 year period. The full set of results is available upon request from the authors.

The 1999 cohort is used as the reference cohort and the 2009 cohort as comparison when examining relative distributions between years, and male cohort as reference with female as comparison when comparing between genders within each year. The relative distributions results are presented in PDF diagrams, where the panel on the left represents the overall relative distributions of the two cohorts, the middle panel represents differences in the two distributions due to location (or median) shift and the panel on the right shows the distributional differences due to changes in the shape of the distribution. Each of the linked horizontal solid lines represents a GHQ score ranging from 1 to 12 for the zero-truncated samples presented here and can be read from the upper x axis labels. The lower x axis

represents the proportion of the population defined by the reference cohort. The y axis defines the relative density, i.e. how much more (or less) density the comparison cohort compared with the reference cohort when the values are above 1 (below 1), and the actual value is the multiplicative factor more (less). The relative density lines below (above) 1 on the y axis indicate the reference (comparison) group has more density. The short dashed lines on two sides of the relative density lines define the 95% confidence intervals of the relative density. The smooth curve is the non-parametric estimation of the relative density function between the two distributions[1].

In contrast to the conventional PDF overlay of two distributions, which requires the viewer to construct the differences between the two curves at each point on the scale, the relative PDF diagrams remain close to the original data and provide simple visual (and numerical) information. The PDF diagrams can be simply interpreted as a density ratio: the ratio of the fraction of respondents in the comparison group to the fraction in the reference group at a given level of the outcome attribute GHQ. The dramatic asymmetry between the reference and comparison cohorts in the upper and lower tails is also easy to see in the relative PDF. The single relative density curve eliminates the need for visual calculations and codes a more natural piece of information: the relative fraction of the population that reports a GHQ score of Y, rather than the relative fraction who jointly report a cumulative share of Y. This allows the researcher to identify detailed differences between two distributions, giving a more accessible and informative description of the data than that afforded by an overlay of, for example, Lorenz curves of the two distributions.

The relative distributions between the female cohorts in 1999 and 2009 are explained in details to demonstrate this intuitively appealing this approach as seen in Figure 1. The overall relative distributions between the two cohorts are shown in Figure 1(a). The relative density above (below) the uniform line of 1 indicates there is more density in the comparison (reference) cohort, which is female population in 2009 (1999). In general, it seems that the 1999 cohort is more concentrated at the upper range (worse psychological well-being, less happy) of the GHQ distribution whereas the 2009 cohort is mostly distributed among the lower range of the GHQ distribution, measured on the reference cohort measurement scale.

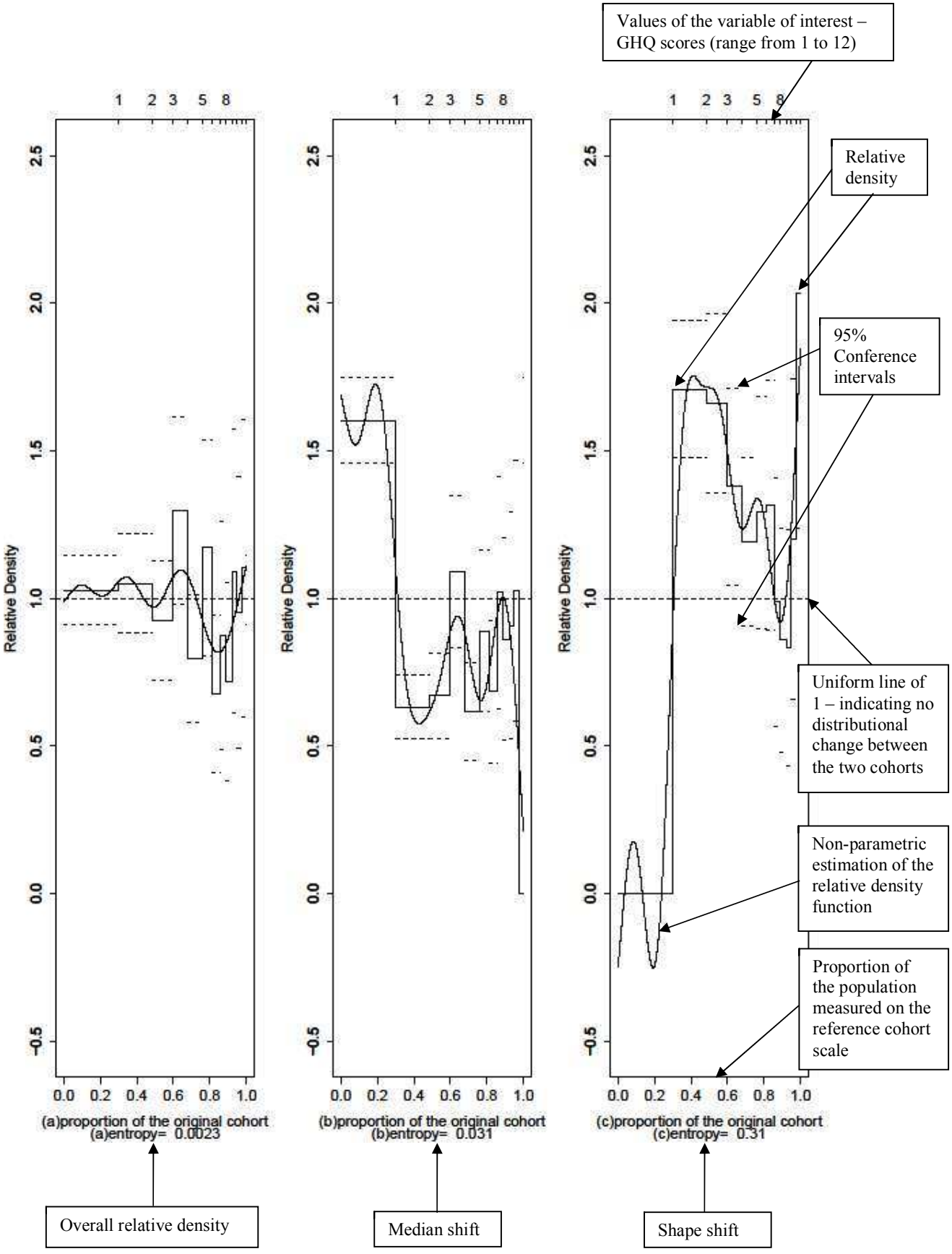
[1] The curve sometimes varies within the same GHQ range, for example, when GHQ score is 1. This is because there are a large number of observations with the same GHQ score of 1, which results in them having the same rank. The smoothing process of non-parametric method needs to smooth the rank out, which introduces variation. As the variations of the smoothing curves always fall in the confidence interval of the relative distributions, they are justified.

For example, reading from Figure 1(a) the relative density when GHQ score is 4 is about 1.3, suggesting 30% more women in 2009 report this level of GHQ score; and the relative density when GHQ score is 7 is about 0.3 – 30% less women in 2009 report a GHQ score of 7.

However, this left-hand side graph alone does not tell us the nature of the population shift from 1999 to 2009, and the decomposition of the overall differences into location and shape changes reveals some important information which would otherwise be overlooked if using conventional methods. The middle and right-hand side panels provide the decomposition of the overall relative distributions: Figure 1 (b) is the shape adjusted location/median change and Figure 6 (c) is the location/median adjusted shape change. The graphs suggest that there is a clear downward shift of the median of the female GHQ distribution in 2009 compared to that of 1999; however, women are more concentrated in the upper tail of the GHQ distribution as shown by the shape change in the left side panel. The 1999 cohort has almost 100% more density at GHQ score of 1, and reading across the bottom axis of Figure 1(c) one can see that this represents about 30 percent of the reference 1999 cohort, while the comparison 2009 cohort is 100% smaller. On the other hand, for most of the GHQ scores above 1, the comparison 2009 cohort has higher density than the reference cohort, for example, at GHQ score of 12 (the last horizontal section of the relative density line), the 2009 cohort has 200% more density, representing though less than 10% of the reference cohort.

The entropy values displayed at the bottom of the graphs provide a summary statistic on how different the relative distributions are from the uniform distribution. From the three entropy values, it seems that adjusting for the median of the 1999 and 2009 distributions, the shape change forms the largest difference between the two cohorts, followed by median change. It is also worth noting that the overall relative distribution is in fact closer to a uniform distribution than its two components of median and shape shifts as the two components show more dramatic change between the two distributions but more in opposite directions. This suggests that the female population has had both a considerable change in median and a substantial change in shape – the median of the female population has shifted downwards on the GHQ scale in 2009 compared to 1999 but the female GHQ distribution has a bigger upper tail in the recent 2009 cohort than the reference 1999 cohort. The effects of both shifts have offset each other and as a result the overall relative distributions are less variable and the relative densities are mostly not statistically significant.

Figure 1, 1999-2009 relative distributions for the female sample truncated at GHQ score of zero



Moving on to other sets of comparisons, Figures 2 and 3 show the relative distributions for the entire sample and male-only sample. In both cases shape change seems to be the major contribution of the distributional differences between the two cohorts. For the entire sample, there seems to be no change in density of population with GHQ score of 1. Generally, the 2009 cohort seems to have higher density at the middle range and very top end of the GHQ distribution, although it is not statistically significant as the confidence interval lines line on both sides of the uniform line of 1. For the male-only sample, the 2009 cohort seems to have moved upwards in the GHQ distribution, generating a heavier right hand tail and a smaller left hand tail.

The different patterns seen in Figures 1, 2 and 3 highlight the differences between genders in the change of GHQ distributions over the 10 year period. Comparisons between the male and female distributions are, therefore, conducted with male population as the reference cohort. In general, men have better psychological well-being than women, as men are more concentrated in the lower half of the GHQ distribution and women have more density in the upper tail of the GHQ distribution. However, decomposition of the overall relative distributions between male and female reveals different nature of the gender differences.

Figure 4 shows the relative distributions between men and women in 1999. There seems to be a clear upward movement of the female GHQ compared to that of men. However, decomposing the overall relative distributions, both median and shape shifts are observed. Figure 4 (b) suggests that the median/location of the female distribution has moved upwards, although Figure 4 (c) indicates higher concentration of female GHQ in the lower tail. The decomposition explains the large differences in the GHQ distribution between men and women. The reason why women have higher GHQ score on average than men is the upward shifting of the female distribution, without which the female distribution is effectively more concentrated in the lower tail of the GHQ distribution. A combination of upward shifting of the median and higher density at the very top end of the GHQ scores is the cause of the higher female average GHQ.

Figure 5 shows the relative distributions between men and women in 2009. Shape change is the main contributor for all comparisons between men and women in 2009 as no location shift is observed. Women are in general more distributed across higher GHQ scores, but the differences between men and women are no longer distinctive.

Figure 2, 1999-2009 relative distributions for the whole sample truncated at GHQ score of zero

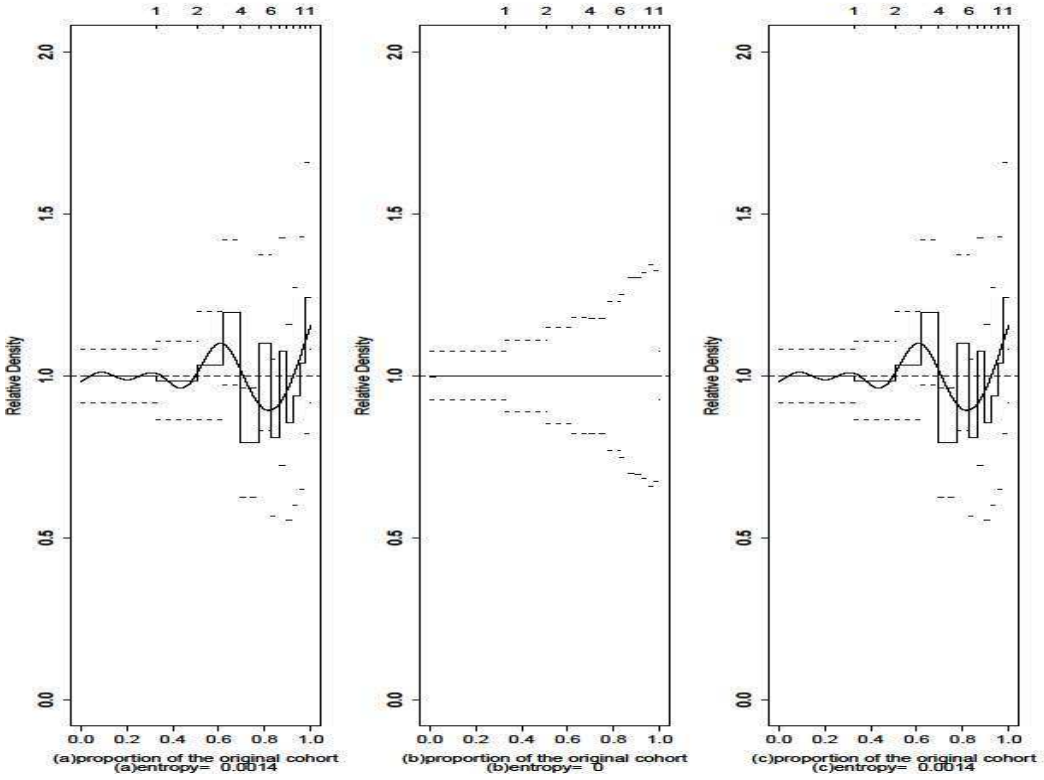


Figure 3, 1999-2009 relative distributions for the male sample truncated at GHQ score of zero

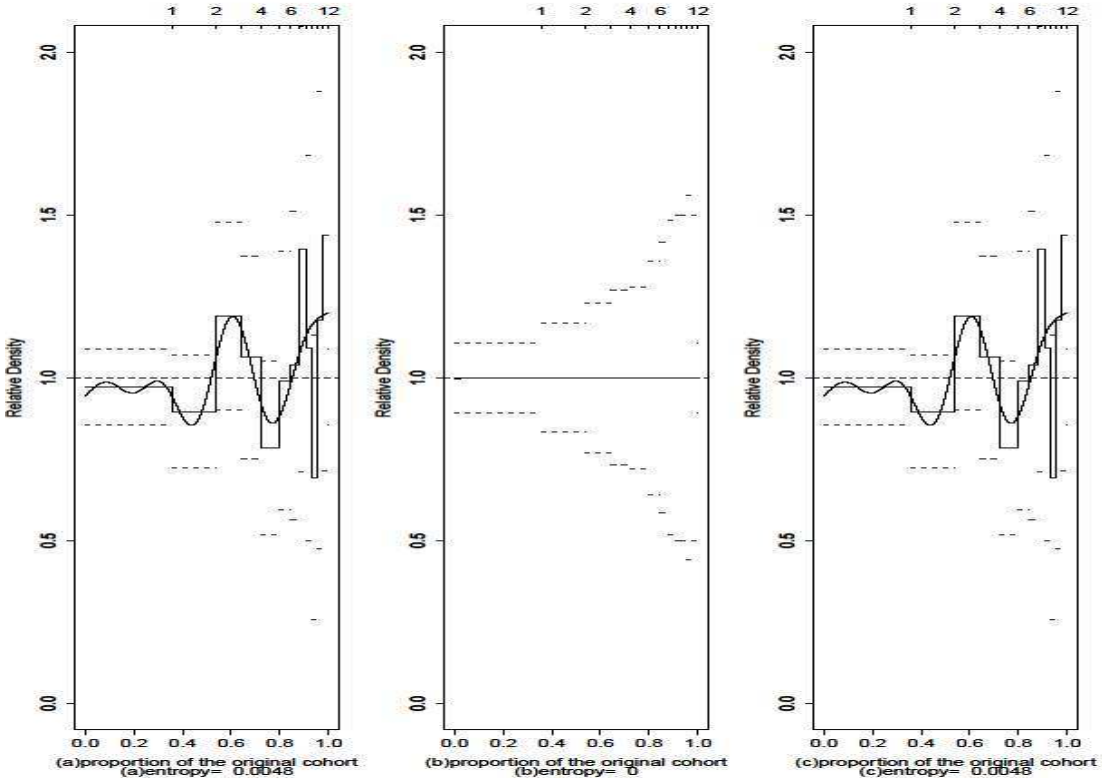


Figure 4, 1999 male-female relative distributions for sample truncated at GHO score of zero

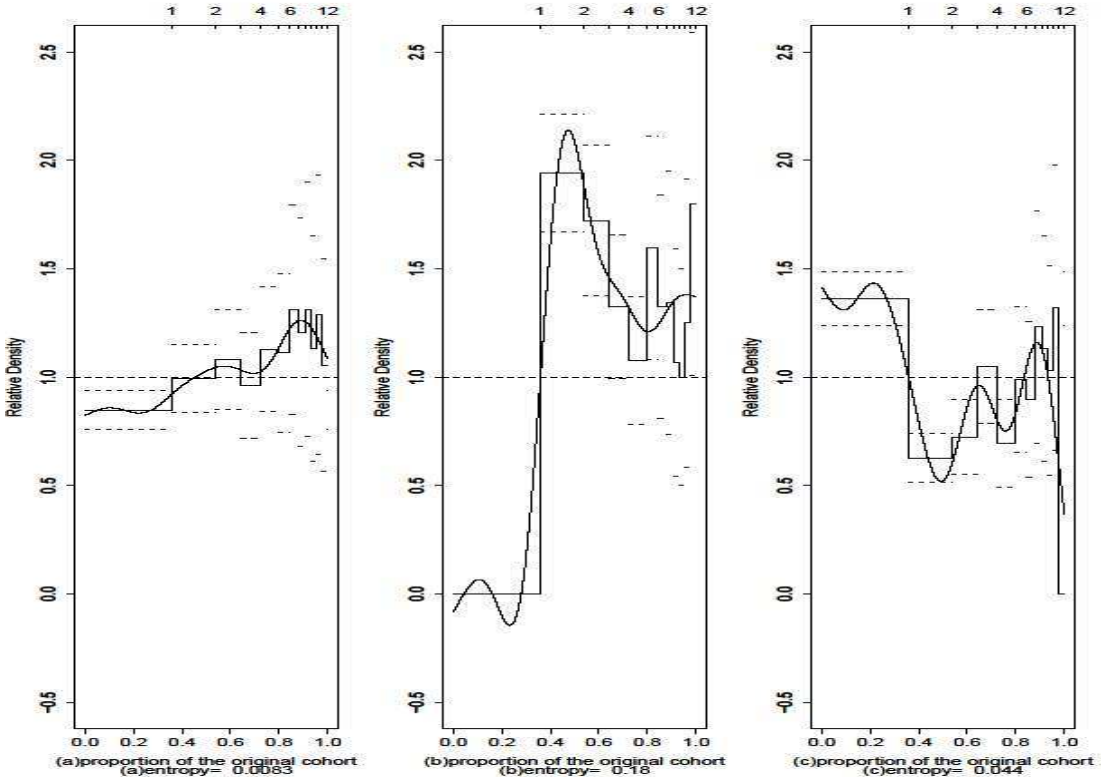


Figure 5, 2009 male-female relative distributions for sample truncated at GHO score of zero

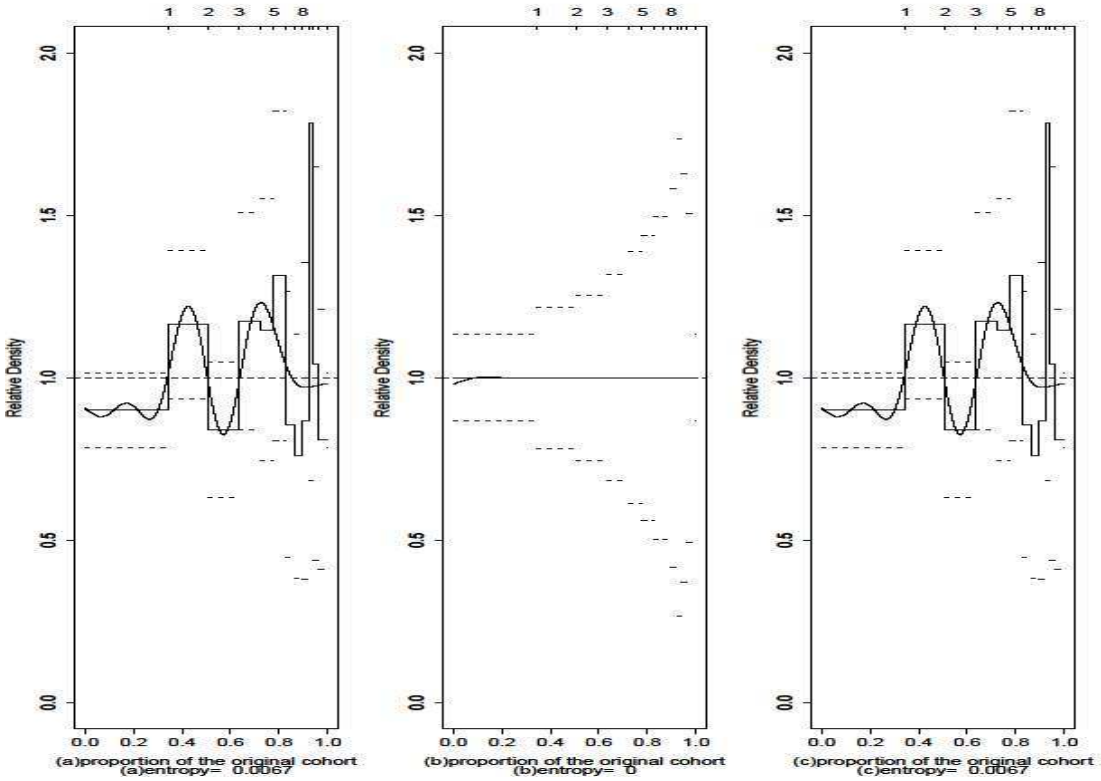


Table 1 displays the polarization indices for the relative distributions comparisons after controlling for median change. As the relative distribution for the entire sample is close to uniform distribution at the lower tail, the lower polarisation index is not applicable in this case. The negative values mean that there is a convergence toward the centre of the distribution. The upper polarization indices for the male-only and female-only samples suggest polarisation – greater inequality in the upper tail, although they are not statistically significant. In 1999 when the male distribution is compared with women's, significant polarization is evident at both the median and the lower tail, suggesting that women's GHQ distribution is more unequal then men's. This is no longer the case in 2009 as seen from the negative polarisation indices for the male-female comparison in 2009.

Table 1, Polarization indices

Samples truncated at GHQ score of 0		Polarization index	95% CI	p-value
Whole sample, 1999 vs. 2009	Median index	-0.205	-0.236 to -0.173	0.000
	Lower index	NA*	NA*	NA*
	Upper index	-0.158	-0.234 to 0.083	0.000
Male-only, 1999 vs. 2009	Median index	-0.186	-0.232 to -0.139	0.000
	Lower index	-0.422	-0.422 to -0.422	0.000
	Upper index	0.061	-0.172 to 0.494	0.139
Female-only, 1999 vs. 2009	Median index	-0.257	-0.308 to -0.206	0.000
	Lower index	-0.934	-0.994 to -0.875	0.000
	Upper index	0.049	-0.041 to 0.139	0.144
1999, Male vs. female	Median index	0.216	0.167 to 0.265	0.000
	Lower index	0.466	0.398 to 0.533	0.000
	Upper index	-0.018	-0.103 to 0.066	0.335
2009, Male vs. female	Median index	-0.217	-0.266 to -0.169	0.000
	Lower index	-0.380	-0.380 to -0.380	0.000
	Upper index	-0.144	-0.262 to -0.026	0.008

*NA – not applicable due to lack of variation between the two cohorts at the lower tail

Discussion

This paper introduces an innovative method – the relative distributions method to investigate inequality, which places no restriction on the underlying functional form and allows the

examination of the entire distribution. An empirical example on inequality and polarisation of psychological well-being using the GHQ measure is presented to demonstrate the method and shed light on the way to investigate the distribution of happiness.

Relative distributions results on the truncated sample excluding GHQ score of 0 are presented. Changes in the shape of the distribution are observed for all the comparisons and are almost entirely responsible for the differences in distributions for the entire sample and the male-only sample between 1999 and 2009. For the female-only sample, a median shift is also observed. The overall trend of the relative distributions between 1999 and 2009 seems to suggest that there is an upward movement in distributional shape at the middle range (GHQ scores of 3 and 4) and very high range (GHQ scores above 10) of the GHQ distribution in 2009. The magnitude of this upward movement is much larger for women than men. However, the shape change in the female distribution is also accompanied by a downward shift in its median, which offset the effect of shape change. Nevertheless, women remain in general reporting higher GHQ scores, indicating having worse psychological well-being than men. But the reason for the gender disparity is different in 1999 and 2009. In 1999, there is a clear distinction that men are more concentrated at the lower tail of the distribution whereas women have dominance in the upper tail. In addition, the median of the female GHQ distribution is significantly higher than that of men in 1999, suggesting the norm of women's psychological well-being and happiness are different from that of men. In 2009, the clear distinction in their dominance of upper or lower range of the GHQ distribution between men and women seems to be disappearing. The difference in norms (median) between men and women is also no longer present. Men continue to dominate the lower tail, but appear to have more density at the upper tail in some GHQ values.

In inequality research, studying distributional polarization is particularly important, as it can reveal any discrepancy in outcomes which would otherwise be hidden when only trends in location are examined. The polarisation indices suggest that a convergence towards the centre of the distribution when 2009 is compared to 1999; however, examining gender separately, a slight increase in inequality at the upper tail of the distribution is observed. Although the observed increased inequality is not statistically significant, it raises concern on the changing patterns of the population's psychological status. As we see that the significantly higher inequality among women than men in 1999 is no longer present in 2009; this, however, does not necessarily mean that the inequality in psychological well-being in women has reduced.

From comparisons between the two years for each gender, it seems that there is a larger increase in inequality in the male population than females, which reduces the difference in inequality between genders. This increase in inequality is occurring at the upper tail of the GHQ distribution, suggesting an increased divergence of psychological well-being among the most worse-offs.

Extending these results to happiness, we observe a reshaping of the distribution of happiness in 2009 compared to that of 10 years ago. Overall, happiness has become less polarised; however, inequality in happiness is higher among people who are less happy, especially for men. There used to be more inequality among women compared to men in 1999, but it is no longer the case in 2009 due to the fact that the happiness of men has become more unevenly distributed among those men who are least happy. Women are less happy than men in both survey years over a decade, but the median of women's GHQ distribution has moved downwards, making the difference in the happiness norm between genders disappear. The finding that women are in general not as happy as men is consistent with others in the literature (Blanchflower and Oswald, 2004, Stevenson and Wolfers, 2009). Some explanations for this phenomenon are suggested, for example, as a result of increased labour market opportunities and greater gender equality that women have enjoyed over the years, women may have increased their expectations and changed their reference group to the men around them (Stevenson and Wolfers, 2009). The suggested explanations are difficult to prove, especially through mean-based methods that do not reveal the whole picture of the shift over years. This study shows that over a decade ago, the majority of women had worse psychological well-being than the majority of men, whereas in recent years, the entire female population has moved towards having the same norm as men with a better median level of happiness, but still differ in how people with different happiness levels are distributed. Thus, the gender difference can hardly be explained simply as a result of change in reference group as the majority of women are in the same location as men with regard to their happiness state. We need to further investigate why the shape of the female distribution is distinctively different from that of men. A better understanding of the causes of women being more distributed at the higher end of the GHQ distribution (less happy) is also required in future research, by perhaps looking into the distribution of socioeconomic factors that are correlated with psychological well-being and happiness.

These key findings have important policy implications. Over the years there is a convergence towards the middle of the happiness distribution – people moving towards having some minor psychological issues with little change in the overall inequality in happiness, but inequality has risen among those who are least happy – a finding which may be overlooked by some conventional method of measuring inequality. To reduce inequality in psychological well-being and happiness, policy interventions would be more effective if they are designed according to how psychological well-being is distributed and target people at different point of the distribution differently, for example, in this case shown, people with the worst psychological well-being should be given special attention. The gender comparison suggests that in order to reduce the inequality in psychological well-being and happiness between men and women, interventions should be designed to target women with the higher level of psychiatric problems, rather than the entire female population.

The application of cross sectional data rather than panel data ensures that the analysis does not suffer from potential selection bias where people who were in a worse psychological state tend to stay in that state. This advantage increases the robustness of the research findings and policy implications. It is, however, worth noting that the results in this paper are unconditional, as the primary purpose of this paper is to demonstrate the method. Further investigation should be conducted controlling for the effect of age, as age is often found to be significantly associated with psychological well-being and happiness, and so are other socioeconomic factors.

Conclusion

This paper introduces the relative distributions method in the study of inequality, with an empirical application to psychological well-being. The relative distributions method has two advantages: i) it allows consideration of the whole distribution; and ii) the scale invariance property means that if happiness is a monotonic transformation of psychological well-being, conclusions regarding inequality in happiness can be drawn. Psychological well-being has attracted growing attention in the health economics literature whereas happiness is an increasingly discussed topic among academics as well as politicians. This paper makes a first attempt to address the distributions of happiness and provides information on the entire distribution that may be otherwise uncovered by crude summary statistics, such as mean or Gini. The study concludes that there is a convergence in psychological well-being and

happiness towards the middle of the distribution among English people, but a slight increase in inequality among the most worse-offs is observed, especially for men. In addition, women continue to have more density at the unhappy end, but the difference in the level of inequality between genders has disappeared and the median of women's happiness distribution has moved downwards, resulting in women having a similar norm as men in terms of psychological well-being and happiness.

References

Blanchflower, D. G. and Oswald, A. J., Well-Being over Time in Britain and the USA. Journal of Public Economics, 88(7–8): 1359–86, 2004

Blanchflower, D. G. and Oswald, A. J., Hypertension and happiness across nations, University of Warwick, Department of Economics, The Warwick Economics Research Paper Series (TWERPS) with number 792, 2007

Clark, A. E. and Oswald, A. J., A simple statistical method for measuring how life events affect happiness, International Journal of Epidemiology; 31: 1139-1144, 2002

Collings, et al., Acceptability of a guided self-help mental health intervention in general practice, Family Practice 2012; 29:43–49

Coyle, A., A study of psychological well-being among gay men using the GHQ-30, British Journal of Clinical Psychology; 32 (Pt 2): 218-20, May, 1993

Department of Health, The economic case for improving efficiency and quality in mental health, supporting document of No health without mental health: A cross-Government mental health outcomes strategy for people of all ages, Department of Health, 2011

Deurenberg, P., Weststrate, J. A. and Seidell, J. C., Body mass index as a measure of body fatness: age- and sex-specific prediction formulas, British Journal of Nutrition, 65:105-114 Cambridge University Press, 1991

De Voe, S. E. and Pfeffer, J., When is happiness about how much you earn? The effect of hourly payment on the money happiness connection, Personality and Social Psychology Bulletin; 35; 1602, 2009

Donatella, et al., The Awareness of Being Observed Changes the Patient's Psychological Well-being in Anesthesia, Anesthesia & Analgesia, 90:739–41, 2000

Frey, B. S. and Stutzer, A., Happiness and economics: How the economy and institutions affect well-being, Princeton/Oxford: Princeton University Press, 2002

Frey, B. S. and Stutzer, A., Economics and happiness: Framing the analysis (chapter 4), Edited by Luigino Bruni and Pier Luigi Porta. Oxford: Oxford University Press, 2005

Gardner, J. and Oswald, A. J., Does Money Buy Happiness? A Longitudinal Study Using Data on Windfalls, Royal Economic Society Annual Conference 2002 with number 81

Gardner, J. and Oswald, A. J., Do divorcing couples become happier by breaking up? Journal of Royal Statistical Society, Series A, 169, Part 2, pp. 319–336, 2006a

Gardner, J. and Oswald, A. J., Money and Mental Wellbeing: A Longitudinal Study of Medium-Sized Lottery Wins, Journal of Health Economics, Vol.26, No.1, pp. 49-60, 2006b

Goldberg D. and Williams P., A user's guide to the General Health Questionnaire, Windsor: NFER-Nelson, 1991

Handcock, M. S. and Morris, M., Relative distribution methods in the social sciences, Statistics for Social Science and Public Policy, Springer 1999

Hankins, M., The reliability of the twelve-item general health questionnaire (GHQ-12) under realistic assumptions, BMC Public Health, 8:355, 2008

Heiat, A., Vaccarino, V. and Krumholz, H.M., An evidence-based assessment of federal guidelines for overweight and obesity as they apply to elderly persons. Archives of Internal Medicine; 161:1194–203, 2001

Jacob, K. S., Bhugra, D. and Mann, A. H. , The Validation of the 12-item General Health Questionnaire among ethnic Indian women living in the United Kingdom, Psychological Medicine, 27, 1215-1217, 1997

Jones, A.M. and Lopez Nicolas, A., Measurement and explanation of socioeconomic inequality in health with longitudinal data, Health Economics 13: 1015-1030, 2004

Kahneman, D., Wakker, P. and Sarin, R., Back to Bentham? Explorations of experienced utility, Quarterly Journal of Economics 112: 375–406, May, 1997

Korten, A. and Henderson, S., The Australian national survey of mental health and wellbeing – common psychological symptoms and disablement, British Journal of Psychiatry, 177: 325-330, 2000

Lyubomirsky, S., and Lepper, H., A measure of subjective happiness: Preliminary reliability and construct validation. Social Indicators Research, 46, 137-155, 1999

Mangalore, R., Knapp, M. and Jenkins, R., Income-related inequality in mental health in Britain: The concentration index approach, Psychological Medicine, Cambridge University Press, 2007

Marín-León, L., et al, Social inequality and common mental disorders, Revista Brasileira de Psiquiatria, vol.29, no.3, São Paulo, 2007

McClements, L.D., Equivalence scales for children. Journal of Public Economics, 8, 191-210, 1977

Michalos, A. C., Global report on student well-being, Vol. 1, Life satisfaction and happiness. New York: Springer-Verlag. pp. 20–28, 1991

Nishi, N., et al, Effects of socioeconomic indicators on coronary risk factors, self-rated health and psychological well-being among urban Japanese civil servants, Social Science & Medicine 58: 1159-1170, 2004

ONS, Measuring national well-being, The Office for National Statistics, 2011

Oswald, A. J. and Powdthavee, N., Obesity, unhappiness, and the challenge of affluence: theory and evidence, IZA Discussion Paper No. 2717. Available at SSRN: http://ssrn.com/abstract=981703, Mar. 2007

Proto, E., Sgroi, D. and Oswald, A.J., Are happiness and productivity lower among young people with newly-divorced parents? An experimental and econometric approach, Experimental Economics 15:1–23, 2012

Schmitz, N., et al., Diagnosing mental disorders in primary care: The General Health Questionnaire (GHQ) and the Symptom Check List (SCL-90-R) as screening instruments, Social Psychiatry and Psychiatric Epidemiology, Volume 34, Number 7, July, 1999

Shannon, C., A Mathematical Theory of Communication, The Bell System Technical Journal,

Vol. 27, pp. 379–423, 623–656, July, October, 1948

Shields, M. A., Exploring the economic and social determinants of psychological well-being and perceived social support in England, Journal of Royal Statistical Society, 168, Part 3, 513-537, 2005

Shields, M. A. and Price, S. W., Exploring the economic and social determinants of psychological and psychosocial health, IZA Discussion Paper No. 396, November 2001

Skodova, Z., et al, Socioeconomic inequalities in quality of life and psychological outcomes among cardiac patients, International Journal of Public Health 54: 233-240, 2009

South Australian Department of Health (Population Research & Outcome Studies Unit), North West Adelaide Health Study: Psychological Wellbeing, Stage 2 Epidemiological Series Report # 2007-07, April 2007

Stevenson, B. and Wolfers, J., The Paradox of Declining Female Happiness, American Economic Journal: Economic Policy 2009, 1:2, 190-225

Theil, H. and Laitinen, K., Singular moment matrices in applied econometrics. In: P.R. Krishnaiah, Editor, Multivariate analysis — V, North-Holland, Amsterdam, pp. 629–649, 1980

Thomas, C., Benzeval, M. and Stansfeld, S.A., Employment Transitions and Mental Health: An Analysis from the British Household Panel Survey, Journal of Epidemiology and Community Health, Vol. 59, No. 3, 2005

Verhaak, P. F. M., et al., Mental health in the Dutch population and in general practice: 1987–2001, British Journal of General Practice, October 2005

Weich, S., et al., Income inequality and the prevalence of common mental disorder in Britain, British Journal of Psychiatry; 178: 222-227, 2001

Werneke, U., et al., The stability of the factor structure of the General Health Questionnaire, Psychol Med; 30(4): 823-829, Jul. 2000

Wildman, J., Income related inequalities in mental health in Great Britain: Analysing the causes of health inequality over time. Journal of Health Economics, 22 2 295-312, 2003

Appendix: General Health Questionnaire (GHQ) 12-item version

Have you recently:
1* Been able to concentrate on whatever you're doing?
2 Lost much sleep over worry?
3* Felt that you were playing a useful part in things?
4* Felt capable of making decisions about things?
5 Felt constantly under strain?
6 Felt you couldn't overcome your difficulties?
7* Been able to enjoy your normal day-to-day activities?
8* Been able to face up to problems?
9 Been feeling unhappy or depressed?
10 Been losing confidence in yourself?
11 Been thinking of yourself as a worthless person?
12* Been feeling reasonably happy, "all things considered"

*these items are positive questions

The options to positive questions are: "Better than usual", "Same as usual", "Less than usual" and "Much less than usual" and to negative questions are: "Not at all" "No more than usual" "Rather more than usual" and "Much more than usual".