**Instructions for Exercise 12: Dominance Analysis**

**Revised September 2020**

**Preliminary Note**

1. The training exercise materials are available here: <https://www.york.ac.uk/che/research/equity/handbook/>
2. There are two spreadsheets: “Ex 12 – student file” and “Ex 12 – solution file”. Please open the “student file” to start with and go through the worksheets filling in the relevant cells yourself. You can look at the solution file if you get stuck.
3. When the spreadsheet is first opened a ‘Security Warning’ may be displayed below the menu bar.  Select ‘Enable this content’.
4. This exercise was produced for the Handbook of Distributional Cost-Effectiveness Analysis by Tom Van Ourti and Owen O’Donnell and edited by Richard Cookson with help from Matthias Arnold and Yukiko Asada.

**Introduction**

The aim of this exercise is to learn how to use the extended Gini family of social welfare functions (SWFs) to quantify and compare welfare and relative and absolute inequality of distributions of health-adjusted life expectancy (HALE). We illustrate how different degrees of inequality aversion affect these comparisons, and stress similarities and differences with welfare comparisons based on dominance analyses (in exercise 11).

The exercise is based on the illustrative example of Nicotine Replacement Therapy in England. Nicotine replacement therapy (NRT) to help people stop smoking or chewing tobacco is a classic example of a preventive healthcare intervention aimed at improving health and reducing health inequality. You are asked to imagine that the UK government is considering three national policy options for NRT in England:

1. No Public NRT: do not provide any public subsidy for nicotine replacement therapy
2. Universal NRT: offer free nicotine replacement therapy to all smokers
3. Proportional Universal NRT: Universal NRT with additional resources to encourage uptake in disadvantaged communities

We provide group-level distributions of health adjusted life expectancy (HALE) at birth resulting from these three options, as calculated in handbook exercises 7, 8 and 9. Your task is to evaluate which of these three distributions is the best, taking into account both efficiency in terms of sum total health and equity in the distribution of health.

**Getting started**

Open *‘Ex 12 – student.xlsx’* and select the <Calculation & EDEH> worksheet.

You must complete the yellow cells.

Table 1 presents the group-level distributions of average health-adjusted life expectancy (HALE) resulting from each of the three policy options – i.e. 1: No NRT, 2. Universal NRT and 3. Proportional Universal NRT. Each distribution is broken down by ten groups, i.e. 5 SES groups ranked from most deprived (1) to least deprived (5) for both the North and South of England.

*Calculating EDEH welfare, relative inequality and absolute inequality*

In this first worksheet you will calculate the generalized extended Gini index of absolute inequality, the extended Gini index of relative inequality and the EDEH (Equally Distributed Equivalent Health) welfare index for each of the three NRT policies for different values of .

1. Complete the column “Group Rank HALE” in Table 1 by calculating the health rank of each group from low HALE (1) to high HALE (10). You should confirm that in this particular example the other two policy options HALE 2 and HALE 3 also lead to the same health ranking of groups.

*Hint: use the function RANK(… ;…;1)*

ii. Check you understand the values that should now appear in Table 2 – the three HALE distributions ranked according to “Group Rank HALE” in Table 1 using the VLOOKUP command, and the cumulative sum of group size.

*Note: The “Weight” column in Table 2 contains the weighting function of the generalized Gini index* , where is the inequality aversion parameter set to 1.05 in the red highlighted cell B19 and is the individual health rank. *This weighing function can be derived from rewriting (see also footnote 11 of chapter 12), i.e. . Erreygers et al. (2012) show that the weighting function suffers from a grouping bias when working with aggregate data. This exercise implements the estimator derived by Erreygers et al. (2012) where stands for group j and where groups are ranked by average HALE, denotes the number of individuals in group j; and the cumulative number of individuals in all groups up to group j.*

iii. In Table 3, calculate the generalized extended Gini index of absolute inequality, the extended Gini index of relative inequality and EDEH welfare for equal to 1, 2 and 3. (Intermediate values for 1.2, 1.4, 1.6, 1.8, and 2.5 have already been completed for you) To do this, fill in the value of in the cell highlighted in red. Then copy and paste the values into the line in Table 3 corresponding to your chosen value of .

vi. You should find that EDEH (=welfare) is highest under HALE 3 and lowest under HALE 1. Absolute and relative inequalities are lowest under HALE 3 and highest under HALE 1, except for very small values of (e.g. ).

*Inequality and welfare orderings, and the equity impact plane for different attitudes to inequality aversion*

This exercise illustrates the comparison of inequality and welfare (EDEH) orderings for different degrees of inequality aversion and compares with the findings based on dominance analysis in exercise 11.

Open the <inequality aversion & EDEH> worksheet.

i. Figure 1 plots the value of *η* versus the level of EDEH for the three policy options, which is a graphical representation of the information in Table 3. Since differences between scenarios appear too small to discern on the scale used in Figure 2, we plot the corresponding deviations from policy option HALE 1 in Figure 2, based on auxiliary calculations in table 4. Confirm that curves cross around *η = 1.3* implying that option 3 has higher welfare when η is larger than 1.3, and option 2 has highest welfare for values smaller than 1.3.

*Hint: these figures are useful to check for crossings of the curves, i.e. to check whether the welfare ordering based on EDEH is robust to the value chosen for . They should however not be used to compare the level of welfare for different values of . In other words only vertical differences between two options for the same value of are informative, while the change in the level of EDEH for different values of is not informative.*

ii. Comparison with the dominance analysis in exercise 11 reveals that the welfare ordering obtained from a SWF can depend on the specific inequality aversion parameter value chosen for the weighting function. We found that option 3 dominated option 2 only after imposing downside positional transfer sensitivity (DPTS), which holds for under the extended Gini family of SWF. In this exercise, we find that under imposition of that SWF, option 3 is still socially preferred to option 2 at lower values of inconsistent with DPTS.

Open the <equity plane & EDEH> worksheet

iii. This worksheet plots the three options in an equity-efficiency plane, with the average health level in HALE on the vertical axis and the negative of the relative extended Gini index of inequality in HALE on the horizontal axis (auxiliary calculations in Table 5). This is done separately for equalling 1, 1.2, 2 and 3. Additionally an indifference curve is added, indicating all combinations of average health and relative inequality that would leave the decision maker indifferent to option 2. Consider: how would things differ if we were to turn this into an equity-efficiency *impact* plane based on incremental comparisons between the options rather than levels of average health and health inequality? How would the indifference curve change? And how would the axes change? (Hint: it would depend on which option we took as the baseline for making incremental comparisons).

iv. Figure 3a shows the equity-efficiency plane for = 1. Confirm that the indifference curve is horizontal as a decision maker with = 1 does not care about inequality and will assign highest welfare to option 2 independent of the level of inequality.

v. Figures 3b-d show similar equity-efficiency planes for respectively = 1.2, 2 and 3. Confirm that the indifference curves become more negatively inclined for higher values of as these corresponds to higher levels of inequality aversion, but also that the value of the relative extended Gini (horizontal axis) changes. Note further than the ranking of HALE 2 and 3 in terms of EDEH switches around = 1.3.

**Optional exercises on EDIEH and socioeconomic-related inequality**

These exercises use the distribution of each programme option broken down by five socioeconomic groups of the English population (and thus neglecting North-South differences) allowing for aversion to socioeconomic-related health inequality.

*Calculating EDIEH, and socioeconomic-related (relative) absolute inequalities*

Select the <Calculation & EDIEH> worksheet.

Calculate the EDIEH (Equally Distributed by Income Equivalent Health) and extended concentration indices proceeding analogously to what you did before to get the EDEH, but replacing health rank by SES rank.

We find that welfare is highest in option 3 and lowest in option 1, while inequality (absolute and relative) is lowest in 3 and highest in 1, provided is not too small. Again, compared to exercise 11 where bivariate DPTS was required, , to find dominance of 3 over 2, this exercise illustrates that parameterization can achieve a welfare ordering in some cases in which dominance does not. However, the ordering obtained through parameterization is less robust than that found by dominance.

*Inequality and welfare orderings, and the equity impact plane for different attitudes to socioeconomic inequality aversion*

Select the <SES-inequality aversion & EDIEH> worksheet.

Plot the value of  versus the level of EDIEH for the different options.

We find that 3 has higher welfare when is larger than 1.3, and 2 has highest welfare for values smaller than 1.3.

Select the <equity impact plane & EDIEH> worksheet.

This shows the equity-efficiency plane for  = 1, 1.2, 2 and 3 with the relative extended concentration index on the horizontal axis.

*Individual versus between group analysis*

As in exercise 11, we analyse health distributions at the group level and so neglect within group variation in HALE. See chapter 11 for further discussion.

**Optional extra web-based exercise**

The worksheets <inequality aversion & EDEH> and <equity plane & EDEH> have been simplified and automated in a web-based tool.

Open the web-based tool at this website: [**https://shiny.york.ac.uk/dcea/**](https://shiny.york.ac.uk/dcea/)

Click on “Evaluate using social welfare functions”.

**Extended Gini social welfare function**

Click on “Gini EDE plot”. Look at the graph entitled “Equity weighted NHB compared with No NRT”. This compares social welfare under the three policies using the Extended Gini social welfare function with different levels of concern for reducing health inequality (“inequality aversion”). Social welfare is measured in EDEH units that are comparable with population total HALYs.

1. At what level of inequality aversion do the two lines cross, such that Proportional Universal NRT has higher EDEH than Universal NRT? What does this mean?
2. Try changing the baseline decision to “Universal NRT”. (Select this in the left hand panel). How and why do the lines change?

Now click on “Equity impact plane”.

1. Try setting the inequality aversion parameter to 1, by moving the slider. What do the results mean? (*Hint: This corresponds to a standard CEA, which focuses only on efficiency in improving total health without concern for reducing health inequality).*
2. Now try gradually increasing the parameter by moving the slider. What happens to the points? Why?
3. Try changing the baseline decision to “Universal NRT”. At what level of inequity aversion does the “Proportional Universal” become clearly better than “Universal NRT”?

**3 fictional individuals**

Download the CSV file *entitled “Ex 12 – three individuals.csv”,* from the handbook supporting materials webpage <https://www.york.ac.uk/che/research/equity/handbook/>

In the left-hand panel of the web-based tool, under “Choose CSV file”, upload this CSV file.

This is the same example used in Chapter 11 of the handbook. To understand the data, first look at the “raw input data” tab. You will see six hypothetical distributions of lifetime HALY outcomes for three individuals, under six different policy options A to F.

Which option do you judge to be best?

To help you decide, you can repeat the equity impact plane analysis above for these fictional examples. Notice, for example, that option C Pareto dominates option A, even though it is more unequal and lies in the North-West “win-lose” quadrant of the equity impact plane.