THE EFFECTS OF INCOME INEQUALITY ON LIFE EXPECTANCY ACROSS THE EU: A PANEL DATA ANALYSIS

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ABSTRACT

This dissertation investigates the relationship between income inequality, as measured by the Gini Coefficient, and life expectancy across the European Union member states via Panel Data Analysis. The model that is built and estimated in this study comprises both contemporaneous income inequality as well as income inequality that is lagged by one year. Total Healthcare Expenditure per capita and Education Attainment are included as control variables in the model, with these variables being measured in Purchasing Power Parity Dollars and the number of years spent in formal education respectively. The Panel Data model is estimated for the period starting in 2003 and ending in 2017 by first using the Pooled Ordinary Least Squares method and subsequently via the more reliable Fixed Effects method in order to ensure the validity of the results obtained. In order to control for socio-economic elements that are difficult to adequately capture though control variables, the Panel Data model is restructured and re-estimated across six sub-categorizations that organise groups of countries according to geographical position, relative Gross Domestic Product as well as the relative ethnic fractionalization of the population.

To investigate in further detail the relationship between income inequality and life expectancy in the EU, a second line of investigation is conducted that is focused on a country by country Ordinary Least Squares Regression analysis and deeper Panel Data analysis.

The results of the Panel Data analysis indicate that both Healthcare Expenditure per capita and Education Attainment have significant roles in determining life expectancy in the EU, although the strength of this influence may vary according to geographic, ethnic and national wealth factors. Initially, the results do not pin down the existence of a negative relationship between income inequality and life expectancy as per the Wilkinson Hypothesis.

The results of the second line of investigation strongly indicate the existence of such a negative relationship between income inequality and life expectancy for Belgium, Estonia, Latvia, Portugal, the Netherlands and the United Kingdom.

The final part of this dissertation outlines the policy implications of these results whilst also proposing avenues for future research on the topic.

Keywords: Income Inequality, Life Expectancy, Wilkinson Hypothesis, Panel Data, Pooled OLS, Fixed Effects, European Union.

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CHAPTER 1

INTRODUCTION

Income Inequality

The debate on inequality is a very important one in economics, partly because of the significant role that inequality plays in influencing other areas of study in the fields of macro and micro economics, but also because of the role that inequality plays in affecting society, the real economy and policy formulation and implementation.

In the years following the end of the Second World War, poverty and income inequality were a significant phenomenon across European countries, despite the strong and persistent economic growth that occurred over the period. In light of this, the reduction of income inequality and the convergence of income levels have always been central objectives behind the formation of the European Union, as prominently expressed in the Treaty on the Functioning of the European Union: *'[T]he Union and the Member States ... shall have as their objectives ... improved living and working conditions, so as to make possible their harmonisation while the improvement is being maintained' (EU, 2007, Article 151 TFEU (ex-Article 136 TEC))*. Furthermore, the issue of income inequality was also addressed in The Five Presidents' Report of 2015, which re-emphasises the importance and urgency of reducing income inequality and achieving convergence within the EU (Juncker et al, 2015). This issue was addressed once again in the European Pillar of Social Rights whereby the third principle focuses on the right of equal opportunities for all, whilst also introducing a Social Scoreboard relating, in part, to income inequality.

In the last few decades, a specific trend has emerged with regard to income inequality within the EU-28 such that it had been falling significantly and persistently in the years leading up to the Financial Crisis and the subsequent European Sovereign Debt Crisis, stabilizing thereafter. Interestingly enough, when the analysis is focused on the Euro Area, it can be observed that income inequality has experienced a small increase over the same period (Filauro, 2018). Furthermore, the negative aspect of these developments are accentuated by the fact that a quarter of European adults, and a third of children are at risk of poverty and are also at risk of experiencing some form of social exclusion (OECD, 2015; Stiglitz et al., 2014).

Income Inequality and Health

While not necessarily prevalent in media or in the consciousness of the general public, and addressed to starkly varying degrees in governmental priorities, income inequality and its potential negative effects on population health is a significant socio-economic phenomenon that has been an observable threat to social welfare for several decades. Particularly in recent decades, the work of authors such as Wilkinson and Pickett, amongst many others, has done a lot in terms of bringing to light evidence that portrays how income inequality has a significant enough influence on population health to merit being considered a legitimate and serious threat to social wellbeing and economic welfare. To this end, the first paper to truly do this was Wilkinson's original paper that highlighted the inverse relationship between income inequality and health outcomes (Wilkinson 1996). The majority of the economic and scientific literature published over the last few decades on the topic (and addressed in detail in the Literature Review chapter) has extensively shown that there is a very strong inverse relationship between income inequality and population health, as well as a whole myriad of different undesirable socio-economic outcomes.

This relationship, its theoretical and empirical basis, as well as the socio-economic channels through which it could possible function, are indeed complex and will be explored in depth throughout this dissertation. Implicitly, the existence of such a relationship has considerable ramifications on policy formulation and implementation as well as the field of economics more generally. Essentially, in a very simplified context, such a relationship would imply that increasing income inequality would bring about poorer health outcomes for the population whilst it should also be expected that relatively more equal societies (from an income inequality perspective) should have better levels of health, ceteris paribus. This phenomenon can be observed across a wide range of measures of population health outcomes ranging from life expectancy, infant mortality, and self-measured health - which are some of the main measures of population health outcomes used in the literature – to measures of health outcomes such as morbidity rates relating to obesity, HIV infection, mental illness and even instances of violence (Babones, 2008; De Vogli et al., 2005; Hales et al.,2000; Kondo et al., 2009; Offer et al., 2012; Pickett et al., 2005; Subramanian and Kawachi, 2004; Wilkinson, 1996;Wilkinson and Pickett, 2006).

As will be explored later on in this dissertation, this relationship is also important to policy makers as evidence exists that suggests that policies and investment relating to health care provision, education attainment and socio-economic mobility can be extremely effective in influencing the income inequality – population health dynamic. Even more broadly, this may also influence, or be of direct relevance, to policy design relating to income redistribution and taxation, the provision of a broad array of public services as well as social welfare policies such as housing and the mechanisms behind macroeconomic automatic stabilizers as well as others that relate to creating equal opportunities and a broader social sense of equality (Rowlingson, 2011).

Moreover, it is also reasonable to assume that deteriorating population health may have a negative effect on labour productivity, human capital and, by extension, economic growth (Subramanian et al, 2002).

In terms of putting the socio-economic importance of the relationship between income inequality and health into perspective, estimates based on data from the USA from 1990 indicate that income inequality caused the same volume of population health damage and fatalities as diabetes, lung cancer, motor vehicle related accidents; homicide, suicide and HIV combined (Lynch et al., 1998).

Purpose of this research

The main scope of this research is to test the Wilkinson hypothesis within EU member states via panel data analysis. The hypothesis proposed by Wilkinson (1996) posits that in developed economies it is the degree of income inequality within the population that is the main determinant of population health, as opposed to other possible causes such as the outright level of income of individuals. It is of utmost importance to emphasise that the principle driving factor in effecting population health under this hypothesis is the nature of the degree of inequality in the distribution of income across a population rather than the income level of individual households. In this sense, the health outcomes of the population are not necessarily determined as the simple aggregation of the effects of household income on household health.

In this regard income inequality would best be defined as the relative difference in income distribution across a population (OECD, 2015) and income as used in the measure of income inequality is itself best defined as "household disposable income in a particular year. It consists of earnings, self-employment, and capital income and public cash transfers; income taxes and social security contributions paid by households are deducted" (OECD, 2020). Income inequality can be measurable as both gross income inequality (which is measured using income pre taxation) and net income inequality (which is measuring using income post taxation). Both of these measures of income inequality vary significantly across countries. However, the cross country variations relating to net income inequality is compounded by the fact that different countries have different taxation systems, causing cross country variation in this measure of income inequality due to the different levels of income tax but also because of the different amount of income redistribution undertaken by government across the population (Rowlingson, 2011).

Research Question

Given the overarching scope of this research and all of the underlying themes, concepts and dynamics, investigating the Wilkinson Hypothesis in the European Union in a manner that could account for within country variations whilst also focusing on the between country differences could be undertaken through orienting the research around the following two questions:

1. Does income inequality consistently have a significant impact on life expectancy across EU member states?

2. Does it vary significantly in member states with differences in specific characteristics?

Through using established economic theory and a priori expectations and combining these with the knowledge derived from empirical evidence already developed, it is possible to build an economic model for the relationship between income inequality and population health within the EU. Applying data to this model and undertaking the adequate econometric and scientific analysis would facilitate the aforementioned research questions to be answered in a systematic way that would formally prove or disprove the Wilkinson Hypothesis in the EU, whilst providing a formalised explanation for the nature of the relationship between income inequality and health, should it indeed exist. Furthermore, the answer to these questions would provide insight in terms of implications for the design and implementation of economic and socio-economic policy at both member state and EU level.

CHAPTER 2

LITERATURE REVIEW

Introduction

The scope of this chapter is to provide a general overview of the literature that exists in relation to the study of the relationship between income inequality and population health, with particular emphasis being placed on the Wilkinson Hypothesis. This literature review covers this topic in depth and delves into the key theoretical concepts and empirical findings that concern the study of the relationship between income inequality and population health. The purpose of the comprehensive nature of this literature review is to cover the salient developments that have occurred in this field of research that are both directly and broadly related to the research question of this dissertation, and in so doing, advise and provide direction for the modelling and analysis that is undertaken in this dissertation.

This literature review is organised as outlined hereunder:

- Early studies on the topic using international data;
- The dynamics of the effect of income inequality on health;
- Population effects;
- Linkages between Income Inequality and the measure of population health;
- The Wilkinson hypothesis in developed countries;
- The role of the degree of income inequality across the population of developed countries;
- The Wilkinson hypothesis in developing countries;
- The role of the degree of income inequality across the population of developing countries;
- Income inequality and the effectiveness of economic growth in improving health;
- The nature of the relationship between economic growth and population health;
- The potential correlation between economic growth and morbidity rates;
- The role of healthcare in affecting population health;

- The role of education in affecting population health;
- Heterogeneity Effects;
- Anomalies that contradict the Wilkinson Hypothesis;
- Modelling the relationship between income inequality and population health;

Early studies on the topic using international data

The relationship between income inequality and population health has attracted a fair amount of interest over the last few decades since the publication of the seminal paper published by Preston (1975), with studies analysing the effects on populations that range in size from communities to countries. The first real evidence for the existence of a significant influence of income inequality on health using international data came about via Kaplan et al (1996) that analysed the relationship across the United States of America at a state level. With regard to studies conducted using international data, the trend is for findings to evidence a strong relationship between income inequality and population health, with such a relationship being found to exist consistently across the USA, Europe and China (Pei and Rodriguez, 2007).

The dynamics of the effect of income inequality on health

As is common with a myriad of phenomena in macro-economics and health economics, it is highly likely that a variable such as the level of health of a population (as captured by a measure such as life expectancy) would be affected by the relative determining factors in more than just a contemporaneous manner. In this regard, it is probable that population health as measured at a point in time is determined not only by the level of income inequality in the same period, but would also be partially determined by the level of income inequality in the time leading to that period (Kawachi and Subramanian, 2004 and Kondo et al, 2011). Furthermore, the momentum and persistence of the lagged effects of income inequality on the level of health in a population could last up to ten or even fifteen years (Subramanian & Kawachi, 2004), whilst it is possible that the effect would be strongest somewhere between five and ten years (Zheng, 2012).

From a practical viewpoint, such intertemporal persistence in the influence of income inequality on health would mean that any change in the level of income inequality in any one period would affect health in that period as well as in subsequent periods until the momentum of this effect dies down over time. Hence, it would be important to point out that it is highly likely that the level of health (as measured by measures such as life expectancy) observed at any one point in time is likely to be determined by multiple observations of income inequality.

Population effects

Wilkinson and Pickett (2006) suggest that the size of the population being analysed may also affect the strength of the relationship between income inequality and health. Analysis of relatively small populations (such as neighbourhoods) may show a weaker relationship between income inequality and health when compared to studies analysing larger populations such as cities or countries. The authors argue that the reason for this is that larger populations tend to exhibit a wide spectrum of socioeconomic strata whereas smaller populations may exhibit such a quality to a lesser degree or may even show elements of grouping by socioeconomic class. It is for this reason that this study was chosen to be conducted at country level and across the European Union.

Kondo et al (2004) also advocate the notion that the relationship between income inequality and health becomes stronger as the value of income inequality surpasses certain general threshold values. Essentially, this would mean that the relationship becomes progressively more pronounced as the income inequality within a population becomes particularly acute. This effect tends to hold regardless of the size of the population being analysed.

Linkages between Income Inequality and the measure of population health

The literature on the causal links between income inequality and population health is still limited. However, the research conducted thus far has essentially isolated four main avenues through which income inequality within a population can have a causal impact on the health of the population.

1. **Structural Avenues.** Studies such as Lobmayer and Wilkinson (2002) make the case that a ‘Structural Pathway’ exists between income inequality and health. This arises from the likely causal link between income inequality and residential segregation by socioeconomic status. Over time, this dynamic can lead to a geo-spatial concentration of poverty in some areas, which could thereby exacerbate the health status of low income individuals and households. It is also not yet possible to rule out the possible existence of a feedback loop whereby households in low income areas face continued deterioration of their relative economic mobility which would therefore reinforce the relationship between income inequality and health.

2. **Social Avenues.** Studies such as Kawachi and Berkman (2000), Lochner, Kawachi and Kennedy (1999) as well as Subramanian and Kawachi (2003) have put forward the concept of the ‘social cohesion and collective social pathway’ whereby the income inequality has an erosive effect on ‘social capital’, which in turn, has a damaging effect on the health of the population. It has also been posited that increasing income inequality could potentially give rise to the social-economic phenomenon of ‘status anxiety’. This concept focuses on the dynamic through which persistently increasing income inequality could result in the perception that individuals believe that they are facing an entrenchment of their place in the socio-economic hierarchy that may cause individuals great stress as they pursue academic and professional paths for self-advancement. This may occur to the extent that the heightened level of stress, in particular if extended over late adolescence and throughout the career life, may result in significant negative effects on the health outcomes of large tranches of the population (Rowlingson, 2011). Furthermore, low socio-economic status in early life and young adulthood in developed countries could give rise to sustained higher levels of the stress hormone cortisol due to psychological phenomena such as the afore mentioned ‘status anxiety’ as well as ‘social evaluative threats’. Such high cortisol levels over time could be a significant factor in

increasing risk of morbidity (such as heart disease) that could be yet another channel through which income inequality could impact population health (Dickerson and Kemeny, 2004).

3. **Policy Avenues.** Another avenue is the ‘policy pathway’ as advocated by Subramanian and Kawachi (2003), whereby income inequality has a damaging effect on population health via the effect of the state of income inequality on policy formulation and policy implementation. Public policy elements such as welfare spending and public education expenditure might be adversely affected from a funding perspective by increasing income inequality – thereby having a negative effect on the health of the population over the long term.

4. **Income Inequality affecting health via crime and violence.**
   Apart from the avenues mentioned above, various studies, as captured elegantly by the systematic review on the topic conducted by Rufrancos et al (2013), have also brought to light evidence that societies and communities that experience relatively higher income inequality tend to exhibit relatively higher rates of crime and instances of violence. In light of this phenomenon, studies such as Pickett and Wilkinson (2015) promote the idea that such violent behaviour and violent crime as induced by income inequality does probably serve as a potential conduit for the damaging influence of income inequality on population health.

The Wilkinson hypothesis in developed countries

Overall, most of the focus of studies investigating the relationship between income inequality and health has been concentrated on developed countries, with the majority of these being investigations targeting the United States of America and European Countries. Generally speaking, studies into such developed economies consistently yield evidence that strongly advocates for the Wilkinson Hypothesis. Indeed, there seems to be a persistent and robust negative relationship between income inequality and the state of population health in the USA and Europe (Babones, 2008; Detollenaere et al. 2018; Herzer and Nunnenkamp, 2014;

Wilkinson and Pickett, 2010). Furthermore, the meta-analysis of nine cohort studies and nineteen cross sectional studies conducted in Kondo et al (2009) shows that these studies did yield mixed results with regard to their findings on the effects of income inequality on health, but overall, the literature does indeed support the Wilkinson Hypothesis – such that income inequality is found to have a significant and independent adverse effect on population health.

Furthermore, perhaps unsurprisingly, evidence for the negative relationship between income inequality and health is most consistent (and similar in its strength) in economies with similar degrees of income inequality as the USA (Lynch and Kaplan, 1997; Kawachi et al., 1997). In that sense, the relative degree of income inequality exhibited by the United States seems to be the threshold that should yield significant evidence for the Wilkinson Hypothesis in developed countries.

The role of the degree of income inequality across the population of developed countries

The concept that the negative effects of income inequality on population health become accentuated when the level of income inequality exceeds certain threshold values is historically prevalent in developed countries, particularly when this dynamic is observed over relatively long periods of time. This is of particular socio-economic importance, as in many developed Western countries increasing economic growth over the last few decades has persistently correlated with a growing income inequality gap. As can be observed in the case of the United Kingdom, the level of income inequality seemingly hovered below the theoretical 'threshold' level in the decades after the Second World War, such that any increases in the level of income inequality over that period had relatively weak effects in terms of influencing health outcomes. The empirical evidence indicates that the United Kingdom must have passed this theoretical 'threshold' sometime in the middle of the 1980s or early 1990s as the increases in the income inequality gap occurring thereafter seemed to have a much more aggressive influence on population health outcomes (National Equality Panel, 2010; and Rowlingson, 2011). It has been suggested that for developed countries such as the USA, this tipping point or 'threshold' level of income inequality could be close to a Gini Coefficient value of 0.3 (Kennedy et al, 1998; and Kondo et al, 2009)

Empirical evidence for the existence and the socio-economic relevance of such a threshold level of income inequality could have significant implications for economic policy design and implementation, as such a concept could put more emphasis on efforts to use fiscal budgetary tools to close the income inequality gap, or at least curtail its growth around a particular level.

In view of this, instances of developed economies having a significantly lesser degree of income inequality than the United States, such as some European countries before the Financial Crisis, may result in a relatively much weaker link between income inequality and health, to the extent that studies on populations in such economies may not find evidence to advocate for the Wilkinson Hypothesis (Hu et al. 2015). It is worth noting however, that such a situation of a relatively low degree of income inequality may not persist and could be extremely susceptible to deterioration in the face of economic down turns. By extension, such downturns could result in the same populations exhibiting increasing levels of income inequality whilst also showing evidence of the Wilkinson Hypothesis - all of this in the space of only a few years (Stiglitz et al., 2014).

Interestingly enough, the robustness of the relationship between income inequality and population health may not be straightforward and could be particularly complex indeed, such that the existence of a statistically significant relationship between income inequality and population health can depend upon which variable is employed as the measure of health (Baek and Kim, 2018). Therefore, while unlikely in most cases, it cannot be ruled out that identical studies on the same population could yield significantly different results if the health measurement variable is altered, ceteris paribus.

The Wilkinson hypothesis in developing countries

Traditionally, the Wilkinson hypothesis is taken to be applicable to developed economies. As a result, there have been considerably fewer studies undertaken that investigate the effects of income inequality on population health in developing countries, as compared to the volume of research work done on the topic in developed countries.

The studies investigating the influence of income inequality on population health in developing countries, taken both as nations and as groups of developing nations, do indeed indicate relatively consistent evidence for the presence of a significant negative relationship between income inequality and health – as measured by life expectancy (Herzer and Nunnenkamp, 2014 and Marmot and Bobak, 2000). This persists to the extent that the relationship remains significant even when the measure of health is not limited to life expectancy. The evidence seems to indicate that there is a strong influence of income inequality on health in developing countries as captured by measures such as infant mortality (Babones, 2008; Flegg, 1982 and Hales et al., 2000).

As with regard to developed countries, the nature of the relationship between income inequality and health at the country level tends to change significantly when examined in a disaggregated manner at regional or metropolitan level due to the accentuated heterogeneities of the populations that would constitute such areas. Interestingly enough, this relationship has a tendency to remain relatively robust for developing countries, such that it remains significant and more or less intact when investigated at a regional level vis-à-vis the relationship obtained when investigating at country level. This is particularly true for large developing countries that are comprised of multiple regions and states such as Argentina (De Maio et al., 2012), Brazil (Rasella et al., 2013), China (Pei and Rodriguez, 2006) as well as India (Rajan et al., 2013). This also tends to hold true for relatively smaller developing countries such as Chile (Subramanian et al., 2003), Ecuador (Larrea and Kawachi, 2005) as well as Eastern Europe after the break-up of the USSR (Marmot and Bobak, 2000). Furthermore, the relationship between income inequality and population health also appears to remain significant, strong and robust across South America when the measure of health is varied beyond just life expectancy (Biggs et al., 2013).

The investigations into the Wilkinson Hypothesis in Brazil are of particular salience amongst developing countries due to the country's large population, stark socio-economic variations amongst the population (both at country, state and municipal levels) and because of the fact that Brazil's population is spread out over a large spectrum of geographic and climatic conditions. Furthermore, there may also be significant variations in sociological and cultural characteristics across the country's population. Therefore, evidence for the Wilkinson Hypothesis in a developing country such as Brazil would give added credence to the notion that the Wilkinson Hypothesis remains significantly valid and persistently valid in developing countries – even when the characteristic composition of such countries may confound the attainment of such evidence. In this regard, the evidence provided by studies investigating the Wilkinson Hypothesis in Brazil indicates a particularly strong and consistent relationship between income inequality and life expectancy (Messias, 2003; and Rasella et al., 2013) .The strength of this relationship is worth particular attention – it has been found that an increase in the income inequality in Brazil equivalent to a 0.01 increase in the Gini Coefficient would decrease life expectancy by 7 months (Messias, 2003).

A key aspect of the studies investigating the relationship between income inequality and health in developing countries that is important to keep in mind is that some developing nations that may differ significantly in socio-political characteristics that can have a deterministic impact on various economic phenomena in such countries that, in turn, may not be captured by the traditional models used to investigate this relationship in developed countries. For instance, developing countries may tend to have relatively less adequate levels of governance, as well as relatively less effective and efficient channels for income redistribution and the provision of goods and services by the public sector – such as healthcare services. Furthermore, in some developing countries, the public sector may lack the adequate financial infrastructure to provide such socio-economic corrective channels outright. Therefore, all of this should be taken in account when examining the relationship between income inequality and population health in developing countries, in order to maintain the scientific validity of the investigation into the topic.

The role of the degree of income inequality across the population of developing countries

Even amongst developing countries, the degree of income inequality may vary significantly, and this is likely to cause some level of heterogeneity across developing countries with regard to the underlying mechanisms and dynamics through which income inequality could be associated with the health of the population. If the Wilkinson Hypothesis were indeed to hold in developing countries, then similarly to what is generally expected and observed in developed countries, wider gaps in income inequality in developing nations should be associated with more acute negative effects on population health. This is evidenced by the significant declines in life expectancy observed in post USSR Eastern Europe that were associated with increasing gaps in income inequality (Marmot and Bobak, 2000).

Income inequality and the effectiveness of economic growth in improving health

The theoretical constructs behind the concept that population health is improved by economic growth are indeed both logical and mechanically sound, and seemingly persistently validated by empirical evidence. Two of the most salient channels through which economic growth could positively impact health could be; an absolute wealth effect that may result, amongst other positive factors, in increased healthcare spending, as well as the possible effect of lessening the degree of income inequality in a population.

It is also highly likely when considering both developed and developing countries, that the degree and acuteness of income inequality has a role in determining the level effectiveness of economic growth in improving health. Essentially, it could be expected that in developing countries where income inequality is relatively large, decreasing income inequality as a result of economic growth may be associated with significant and rather strong positive impacts in bringing about improvements in the level of population health. Whereas, on the other hand, when the level of income inequality is already relatively small, the positive effects of decreasing income inequality that may arise from economic growth in improving the level of population health may be severely dampened to the extent that economic growth under such a scenario would contribute only modestly to improvements in the level of health within the population.

The influence of economic growth in positively impacting population health may be strong and consistent in both developed and developing countries. However, it is possible that such a relationship between economic growth and population health improvements may show some characteristics of diminishing marginal returns in terms of health improvements for economic growth arising in relatively advanced or well developed countries. It has been hypothesized that such a phenomenon may exist due to the nature of the human body, such that even with increased economic growth, access to healthcare and technology improvements, the longevity of the human being can only be extended so far. Therefore, economies and populations that are already at the outer frontier of healthcare access, and healthcare outcomes could potentially stand to gain increasingly less from persistent economic growth in terms of population health improvements (Olshansky, Carnes, & Désesquelles, 2001; and Pop et al. 2013).

While not necessarily limited to life expectancy as the measure of health, this concept of an upper bound constraint in population health improvements arising from economic growth may be most accentuated and observable with life expectancy due to the fact that other measures of health such as infant mortality may be more easily improved upon whilst, statistically and practically speaking, it is probably easier to push a mortality rate towards a virtual zero than it is to push a measure of longevity such as life expectancy above an abnormally high number of years.

It is extremely difficult to propose what approximate average value of life expectancy would represent such a ceiling, and this task is complicated further by the fact that countries such as Japan have seen a large number of individuals living above the age of 100 (Oeppen and Vaupel, 2002). This is complicated even further by the fact that Japan (and the small islands that have seen such an increase in life expectancy over the last three decades) outperformed countries with more complete public healthcare systems with similar or superior economic growth over the period, suggesting that the causal underlying relationships may be more complex, possibly reflecting the significant role that diet and lifestyle have in determining population health outcomes. It has also been posited however, that under specific situations, extended periods of sustained economic growth coupled with adequate healthcare and the right pre-existing socio-cultural conditions could indeed result in a scenario whereby life expectancy could potentially exceed and be kept above such a ‘ceiling’ (OECD, 2015).

The nature of the relationship between economic growth and population health

Whilst economic growth can influence the health of a population through various channels, one of the key manners through which this occurs is through the effect of a increases in the income levels of individuals. While the general consensus in the literature is that this channel is indeed consistently significant, there is much debate on the nature of this relationship, particularly with regard to whether the relationship between growth in income and health is linear or curvilinear. It could well be the case the nature of this relationship varies significantly depending on the underlying characteristics of the economy and population in question.

For instance, it has been suggested that this relationship would be linear in countries that have relatively low levels of income inequality and relatively strong welfare states, such as Scandinavia (Martikainen, et al. 2001). A linear relationship may also arise if such analysis is carried out over a middle income range population (Mackenbach et al, 2004). With such a linear relationship, economic growth, and the increase in income that it would bring about would result in pari-passu increases in the measure of health for the population. On the other hand, it is possible that this relationship may be observed to take more of a curvilinear form if the analysis is focused on a population of individuals in the higher income range. Such a curvilinear relationship would suggest that if economic growth and the increases induced would rise beyond a certain threshold amount, then the resulting positive effects on the measure of health would dampen down significantly – potentially becoming extremely small or even negligible quite quickly (Mackenbach, et al., 2004). The latter argument could be tied into the ‘ceiling effect’ that can arise when economic growth struggles to increase the health measure of a healthy, economically and medically advanced population (discussed in more detail in the previous section).

Generally speaking, to reaffirm what has already been stated, even when considering all the various idiosyncrasies of developing countries, the evidence from developing countries seem to reaffirm the Wilkinson Hypothesis such that there does indeed seem to be robust impacts of income inequality on the health - as measured by life expectancy of the population (Herzer and Nunnenkamp, 2014).

It is worth noting that the strength of the influence of economic growth and income inequality in bringing about improvements in population health may vary when the population is disaggregated by gender (Baek and Kim, 2018).

The potential correlation between economic growth and morbidity rates

As already outlined, both decreasing income inequality and positive economic growth tend to have strong and persistent associations with improvements in population health, as can be measured by variables such as increased life expectancy, amongst others. When life expectancy is used as the measure of health outcomes for the population it is worth keeping in mind that there may be a statistical correlation between economic growth and the rate of incidence of diseases such as cancer amongst the population. Such a correlation would arise due to the tendency of economic growth to increase life expectancy, creating a scenario whereby a larger pool of the population live significantly longer than their ancestors and thereby reach the threshold age at which the risks of cancer morbidity and other incidence of disease rise sharply.

The role of healthcare in affecting population health

As outlined in the health production model proposed by Grossman (1972), health can be viewed as behaving similarly to a stock of capital that can, and will, deteriorate over time unless investments that reinvigorate health are undertaken. In view of this, the delivery and usage of healthcare should be seen to be a form of investment that can improve the stock of health outright, or slowdown its deterioration. Extrapolating this concept and applying it across a population would imply that the observable value and state of population health would be influenced by the amount of healthcare received by the individuals that make up that population. Taken into the context of this research, this would mean that even in a population wherein the Wilkinson Hypothesis is prevalent, the level of population health at any one point in time is likely to be at least partially determined by the structure and sophistication of the healthcare system (J. Detollenaere et al, 2018) or, to be less specific, the level of access that the population has to healthcare. Essentially, the presence of broad and efficacious healthcare systems can have a persistent, non-ignorable effect that offsets some of the deteriorative influence that income inequality may have on health (Dabla-Norris et al., 2015; Kringos, 2012; Shi et al., 2003; Starfield, 1994; WHO, 2008).

The nature of the provision of healthcare in Europe is characterised by significant variation in the organisation of healthcare systems across countries (Masseria et al., 2009). In light of this, there is likely to exist significant heterogeneity amongst European countries with regard to the effect that healthcare has in offsetting the negative effect of income inequality on health – not only in the volume of this effect but also in how broadly this effect is dispersed across the different socio-economic strata of the population. Therefore, the role of healthcare, as a variable in an economic model could be captured well via healthcare expenditure per capita.

The role of education in affecting population health

Taken from the point of view of the aforementioned health production function of the Grossman model (Grossman 1972), the process of the attainment of formal education, in a similar fashion to the level of income of the individual, can be thought of as playing a role in how individuals demand healthcare related goods and services whilst also potentially playing a role in determining the degree to which individuals are able to maintain their stock of health by slowing down its deterioration over time. Such that the demand for healthcare of an individual will increase with their level of education attainment, particularly so if the marginal efficiency of capital elasticity with respect to education is greater than one and therefore elastic (Ehrlich, 1978). While it is indeed important to take the role of education (via some measure such as attainment or access) into consideration when investigating the relationship between income inequality and population health, empirical findings indicate that it is quite probable that education will only have limited, possibly inconsistently significant power in explaining the relationship or indeed cross country differences in the relationship (Subramanian, 2003; Subramanian and Kawachi, 2003; Blakely and Kawachi, 2002). It is much more probable that access to healthcare and healthcare spending have much more significant and consistent explanatory power in this regard. For the most part, a very popular measure of education attainment in the literature is the number of years spent in formal education.

The ratio of school enrolment could also be used as a successful measure to gauge education attainment and its resulting effect on population health. To this end, similarly to other measures of education, increases in school enrolment ratios are associated with significant increases in life expectancy at birth for both sexes, as well as life expectancy at 65 for both sexes. The positive effect of school enrolment on population health remained significant and consistent when the measure of population health outcomes was changed from life expectancy to the infant mortality rate (Baek and Kim, 2018). In this regard, it is quite important to note that the strength of the influence of school enrolment on population health outcomes was equally strong for both genders, which may not necessarily be the case for the influence of changes in income inequality on population health across the genders or increases in economic growth on health across the genders.

The illiteracy rate is also viable for use as a measure of education attainment. It is worth noting that using the illiteracy rate as a measure of education attainment may be quite effective in having explanatory power in a model studying the relationship between income inequality and health in developing countries, as there would most likely be significant variation in the literacy rate across the population (Messias, 2003). With developed countries, there may still be variations in the illiteracy rate across the population, but to a much lesser degree than developing countries. Furthermore, in developed countries, only relatively small segments of the population would be associated with the higher rates of illiteracy – whereas in developing countries significantly large portions of the population may be associated with the higher levels of the illiteracy rate. It is for this reason that the illiteracy rate may be used as a relatively suitable alternative measure for level of education attainment of the population for developing countries, but not so for developed countries.

While the validity of using the illiteracy rate as a measure of education attainment in such studies on developed countries has been played down considerably due its limitation in such populations, there is yet another reason that advocates for the validity of using the illiteracy rate as the measure of education attainment in models that investigate the relationship between income inequality and population health in developing countries. The illiteracy rate can have relatively significant independent explanatory power in explaining variations in life expectancy in developing countries, particularly so amongst the lower end of the income distribution of the population. By way of example, it has been suggested that an increase in the illiteracy rate of 10 units in Brazil could be associated with a decline in life expectancy of around 2.2 years (Messias, 2003). It could be assumed that this phenomenon may arise as individuals with relatively high levels of illiteracy would find themselves in the lower socio-economic classes and may therefore be exposed to poverty and the wholesale adverse effects that poverty has on health. Furthermore, such high illiteracy might increase the risk of morbidity or injury due to possible hindrances for the individual to monitor what they consume whilst also potentially hindering the ability of the individual to interact with the engineered environment in a safe manner.

Heterogeneity Effects

1. Ethnic Heterogeneity Effect

Due to the fact that cities and communities, as well as countries have starkly different compositions with regard to the residential distributions of ethnic groups, many studies investigating the potential effects of income inequality on population health using international and national data have attempted to control for ethnic heterogeneity across the populations studied. In this regard studies such as Subramanian and Kawachi (2003), Subramanian and Kawachi (2003), Subramanian and Kawachi (2004) as well as Ash and Robinson (2009) study the influence of income inequality on population health whilst controlling for ethnic heterogeneity and indicate that controlling for ethnic heterogeneity across the populations studied does not mute the significant relationship between income inequality and population health. It is worth noting however, that this may not always be the case, as ethnic heterogeneity could indeed have some explanatory power vis-à-vis the correlation between income inequality and population health – as evidenced by Deaton and Lubotsky (2003) wherein the proportion of residents of Afro-American ethnicity explained a significant degree of the association of income inequality and health across metropolitan areas of the USA.

2. Cultural Heterogeneity Effects

It is also possible that the underlying (and entrenched) political and cultural characteristics and social norms of a population may also play some role in influencing the relationship between income inequality and health (Eckersley, 2006; Navarro and Shi, 2001). Moreover, should this indeed be true, then the significant variation in political and cultural characteristics and social norms across European countries (possible accentuated in the differences between Northern and Southern countries) may have some causal effect in the cross country variations in the strength of the observable relationship between income inequality and population health. The nature of such characteristics may be rather difficult to measure and systematically capture in a control variable that can be used for the purpose of economic modelling. Therefore, the inability to accurately pin down these effects due to the presence of such variations may indeed give rise to some elements of vagueness when making cross country comparisons with regard to the investigation of the Wilkinson Hypothesis.

3. Heterogeneity effects arising from differing levels of educational attainment

Differences in the level of education attainment are key heterogeneities across individuals that constitute the populations of countries. This heterogeneity in the level of education attainment is a phenomenon that tends to exist in the data across countries. Whilst these differences are rather stark when comparing across the entire spectrum of countries for which data exist, this heterogeneity in the level of education attainment persists significantly even when countries are grouped into a developed group and developing group. Whilst such a clustering does indeed lessen the degree of difference in the level of education attainment, the differences remain nonetheless.

It is only natural therefore, that such significant intra-country differences in the level of education attainment could play a role in complicating any analysis into the relationship between income inequality and population health (Lynch and Davey Smith 2002). In light of this, the possibility that education attainment could play a key role in the income inequality – population health relationship cannot be ruled out. The level of education attainment within and across populations could have significant explanatory power in determining some aspects of the health outcomes of a population (Baek and Kim, 2018). In light of this, the level of education attainment could potentially have a significant role in determining population health or income inequality to the extent that any relationship between income and health could disappear if educational attainment is employed as a control variable (Muller 2002) albeit across regions and states rather than countries. It is worth noting however, that the majority of the literature investigating the effects of including such a control variable indicates that controlling for variations in educational attainment will not render the relationship between income inequality and health insignificant (Subramanian, 2003; Subramanian and Kawachi, 2003; Blakely and Kawachi, 2002). Therefore, considering the weight of empirical evidence, it is highly probable that controlling for cross country heterogeneities in access to healthcare or outright healthcare spending per capita is more important than controlling for cross country heterogeneities owing to differences in the level of educational attainment.

Anomalies that contradict the Wilkinson Hypothesis

Counterintuitively, there may be instances whereby decreases in income inequality may actually be associated with a worsening state of health for certain strata of the population.

1. Stress at work

Higher income positions may be prone to an increased exposure to work related stress and other psycho-physical ailments. Should the conditions be just right, this phenomenon may manifest in statistical findings as certain tranches of middle to higher income households could register worsening states of health that can correlate with a decrease in income inequality in the economy (Herzer and Nunnenkamp, 2014). Should this effect be large enough, then statistical findings may actually appear to contradict the Wilkinson Hypothesis.

2. Potential Income and Substitution Effects

Increasing income inequality may also appear to correlate with improvements in the health of a population due to potential consumption behaviour that arise from permanent income changes of individuals as well as from the nature of superior goods characteristics of certain elements of healthcare. This may be manifested in a situation whereby an increase in income inequality arising from increases in the incomes of higher income households that is not offset by increases in the incomes of the relatively poorer households may induce an increase in demand for high quality medical services by the higher income households that may benefit their health significantly enough to statistically improve the measure of health captured by the whole population (Miller and Paxson 2006). Hence, statistically speaking, the health of a population may be observed to improve marginally at a time when income inequality within that population is increasing.

3. Meltzer-Richard Theorem

The Meltzer-Richard Theorem puts the median voter at heart of the mechanism behind the size of government as well as the dynamics of taxation policy and the volume of the income redistribution function within that economy. From this perspective, should the earnings of the median voter fall below the mean of the economy, then it is highly probable that the hypothetical voter would vote for an administration that would be in favour of highly redistributive fiscal policies (Meltzer and Richard, 1981). Taken from this point of view, it could thereby be understandable that an increase in inequality within a population may result in higher public sector expenditure on healthcare (Herzer and Nunnenkamp, 2014). Such a socio-economic dynamic could result in the statistical phenomenon whereby an increase in inequality would be observed to be strongly correlated with an increase in the health of the population (possibly as measured by life expectancy) due to the afore mentioned effect as predicted by the Meltzer-Richard Theorem.

Modelling the relationship between income inequality and population health

Investigations into the Wilkinson Hypothesis can be undertaken by showing the existence of a strong negative statistical relationship between income inequality and population health, or better still, by showing the existence of a causal relationship between income inequality and population health - with the latter having much more significant scientific meaning. The standard approach to establishing such a causal relationship is to use economic theory regarding the assumed relationship between variables and multivariate analysis in order to build a model and isolate the effects that an independent variable such as income inequality would have on a dependent variable such as life expectancy (or any other measure of health outcomes) whilst introducing control variables to control for heterogeneities in characteristics that could potentially have independent effects on life expectancy or income inequality (Rowlingson, 2011). Studies that investigate the relationship between income inequality and population health mainly tend to be based on panel data or aggregate level cross sectional data.

Aggregate level cross sectional data is usually used in studies that are limited in scope to establishing correlation relationships between variables and does not tend to be used in studies that attempt to establish causal relationships. The use of aggregate level cross sectional data also gives rise to analytical issues arising from the fact that existence of a correlation between income inequality and the health outcome variable could reflect a relationship between the two variables at the level of the individual member of the population (correlation between the relative income of the individual and his/her level of health) rather than a legitimate relationship between the actual health of the population and the level of income inequality within the population as a whole (Gravelle, 1998).

It has been suggested that while the relationship between income inequality and population health is strong and consistent in both cases, the relationship is relatively stronger for within-country studies than for studies involving cross country comparisons. (Kondo et al, 2011).

The use of multi-level data and panel data

Furthermore, the employment of techniques relating to the use of multilevel data is extremely important for investigating the potential influence that income inequality has on population health. This is due, in part, to the fact that the use of multilevel data facilitates the separation of the effects of the absolute income levels of individuals from the effects of the relative levels of income vis-à-vis the population. Multilevel data is essentially data that is comprised of multiple nested levels – such that each level could be the cause of variability. This occurs as the use of multilevel data allows for the consideration of both the income levels of individuals as well as the nature of the distribution of these income levels across the population. In this regard, the use of simple regressions, multiple-linear regressions and panel co-integration techniques are all econometric techniques that are commonly used in studies that investigate the relationship between income inequality and population health.

Panel data is multidimensional economic data collected on multiple economic variables generated by a number of economic units (such as countries) over a period of time such that the data collected belongs to the same specific economic units and follows these units over multiple time periods. The use of panel data is prevalent in studies that investigate this relationship from a cross country perspective. The use of panel data and the econometric techniques that relate to panel data have the added advantages of facilitating analysis based on clustering, which is highly relevant in cross country analysis of the effects of income inequality on population health due to the fact that it often makes sense to group countries by some key characteristics (such as developed and developing) and also because such techniques afford researchers possible avenue to deal with the significant characteristic heterogeneities that can exist between countries – particularly so if such heterogeneities are concentrated in particular segments of the countries under examination.

CHAPTER 3

MODEL, METHODOLOGY AND DATA

Model and Methodology

After obtaining insights from researching the literature and understanding the nature of the panel data available, the model will take the following form:

$$LE_{it} = \zeta + \beta_1 Gini_{it} + \beta_2 Gini_{it-1} + \beta_3 \delta_{it} + \beta_4 \Omega_{it} + e_{it}$$

Where:

ζ – The intercept term (base natural duration of a human life).

LE = Life Expectancy at Birth (in years)

Gini – Gini Coefficient

δ - Healthcare Expenditure per capita

Ω - Education Attainment (years spent in formal schooling)

e – Error term

i – Denotes the specific country

t – Denotes the year

The intercept term in this model represents the base natural duration of a human life in a given country before factoring in the effects of the independent variables. In such a model, the parameter β_1 would represent the permanent change in life expectancy that would be brought about by a one unit increase in the contemporaneous Gini coefficient. Also, the parameter β_2 would represent the permanent change in life expectancy that would be brought about by a one unit increase in the lagged Gini coefficient (related to the period prior). Given that it is highly unlikely that income inequality will have a pronounced instantaneous effect on life expectancy, it is reasonable to expect that the value of β_2 will be higher than that of β_1. The parameter β_3 represents the permanent change in life expectancy resulting from a unit increase in healthcare expenditure per capita (best observed on a basis of increases worth per Eur 1000). Finally, the parameter β_4 represents the permanent change in life expectancy that would result from an increase in education attainment equivalent to one additional year of formal schooling.

The validation of choosing the Gini Coefficient as the measure of income inequality

The measure taken for income inequality is the Gini coefficient, which in the literature tends to be the preferred indicator of income inequality within a population. The Gini coefficient is derived from the Lorenz curve and varies in value from 0 to 1, where 0 would indicate perfect equality in income distribution whilst a value of 1 would indicate perfect inequality in the distribution of income in society (J. Detollenaere et al., 2018).

The preference of researchers to employ the Gini coefficient stems from its relative attractiveness due to having the characteristic of being generally representative of entire populations as opposed to per capita measures which are not truly representatives of large tranches of the population under study (J. Detollenaere et al., 2018). The Gini coefficient is also preferred to other measures as it is robust to awkward sensitivities from the actual underlying income distribution due to the normalisation of the components used in the computation of the Gini coefficient, namely; the cumulative population and the cumulative share of income (Litchfield, 1999).

It is however important to take into account one of the main disadvantages of the use of the Gini coefficient as the measure of income inequality in an economic model is that the methodology behind the computation of the Gini coefficient is such that the quantification of income inequality does not capture where or exactly how the income inequality within the population arises. Per se, it is completely possible that completely different distributions of income within a population may give rise to the exact same value for the Gini coefficient. It is therefore extremely important that any analysis performed on an economic model constituting the Gini coefficient focuses only on the absolute value of the income inequality within that population without making any assumptions or drawing any conclusions with regard to how that income inequality permeates the various strata of the population in question.

The validation of choosing Life Expectancy as the measure of population health

Life expectancy is a very commonly used measurement of population health outcomes in economic studies on this topic. Life expectancy in its broadest sense is defined by the World Health Organisation (WHO) as '[the] [a]verage number of years that a new born is expected to live if current mortality rates continue to apply'. The life expectancy at birth is defined as 'the overall mortality level of a population'. Furthermore, life expectancy at birth 'summarizes the mortality pattern that prevails across all age groups - children and adolescents, adults and the elderly (WHO, 2006). In the literature, for the purpose of economic study, life expectancy at birth is usually disaggregated by gender or by cohort.

Whilst data and statistics for life expectancy at birth are published by multiple highly reliable sources such as Eurostat, the World Health Organisation and the Institute for Health Metrics and Evaluation (IHME), the methodologies employed to calculate these statistics tend to be standardized and tend to differ very little from one institutional source to another with the computation derived from information on mortality statistics, registered deaths and population counts over a specified calendar period (Preston et al 2001). The generation of such statistics is dependent on the availability of high quality mortality and population data or data for which adequate adjustment for mismeasurement can be made.

Using life expectancy as the measure of population health outcomes as a variable in an economic model for use in the study of the relationship between income inequality and population health has considerable advantages over other measures of population health outcomes. First and foremost, it is a universally understood and accepted metric that is calculated in a non-controversial manner and is published by multiple highly respected supranational organisations for a very large population of countries whilst being subject to regular revision for the sake of accuracy. Furthermore, whilst it is extremely useful as a variable in and of itself, it can be disaggregated in various ways (such as be gender, age group or socio-economic status) in order to allow more in depth modelling and analysis – all whilst maintaining its accuracy and statistical integrity.

There are also downsides to using life expectancy as the measure of population health outcomes in an economic model. To begin with, as a statistic, life expectancy at birth (that is not specifically being adjusted) does not directly factor in health developments or outcomes that are non-fatal in nature such as acquired disabilities or health developments that reduce quality of life that do not shorten the natural life of a human person. This characteristic gives rise to two specific problems. Firstly, it means that life expectancy is not perfect at capturing the health outcomes of a population (all measures fall short in some way) and secondly, it may dampen the statistically observable effects that improvements in healthcare delivery and changes in income inequality may have in improving the health of population. Essentially, the latter point implies that positive and beneficial developments in income inequality and healthcare delivery may actually have a significant impact in improving the health of a population (such as health related quality of life improvements) but some of these real world effects would not be captured by sufficiently large improvements in health as measured by life expectancy if they do not directly and immediately lengthen human life.

The validation for the inclusion of health care expenditure per capita in the model

As explained in depth in the Literature Review, the provision of healthcare can play a significant role in influencing the health of a population, to the extent that this may hold even when the measure of population health outcome is varied. Furthermore, the varying degrees of access to quality healthcare and the presence of effective healthcare infrastructure can significantly and persistently have an offsetting effect that counteracts some of the health deterioration arising from the presence of income inequality. Furthermore, the effect of healthcare in terms of playing a role in the income inequality – population health dynamic is much stronger and more broadly persistent than that of attainment of education. (Dabla-Norris et al., 2015; J. Detollenaere et al, 2018; Kringos, 2012; Shi et al., 2003; Starfield, 1994, 2001; WHO, 2008).

As previously emphasised, there are significant heterogeneities amongst European countries in terms of the relative size and nature (public provision, single payer, third party payer etc) of the healthcare systems as well as the level of access to healthcare (Masseria et al., 2009). For these reasons, the optimal way to capture access to healthcare in an economic model using panel data would be to include healthcare expenditure per capita. In so doing, the effects in terms of access to healthcare arising from public provision and private provision could both be captured adequately and in a uniform, systematic manner.

The validation for the inclusion of education attainment in the model

As discussed at length in the literature review section of this study, education, regardless of the various means through which it can be measured, tends to be significant in affecting life expectancy in the studies conducted throughout the body of literature on the topic. Whilst education attainment is a very enticing control variable to use in a study such as this one, it is worth keeping in mind that the degree of significance and the overall consistency of the impact of education (in its various forms) in impacting life expectancy can vary significantly (Messias, 2003; Subramanian, 2003; Subramanian and Kawachi, 2003; Blakely and Kawachi, 2002).

The inclusion of education attainment can also be validated on the grounds that the positive and significant impact of education attainment on population health, tends to remain consistent regardless of the means used to measure the level of population health (Baek and Kim, 2018).

Introduction of lagged term for Income Inequality

The findings of empirical studies such as Kawachi and Subramanian (2004) and Kondo et al (2011) indicate that there may exist an element of inertia in the manner with which the income inequality within a population impacts the measure of health of the population. Hence, the inclusion of a time lag between income inequality and health is likely to give rise to a more consistent relationship between income inequality and life expectancy. It is for this reason that the Gini coefficient variable will be included in this model both at time t and at a lag at time t-1.

A Priori Expectations

A priori, if the Wilkinson hypothesis does indeed hold in the EU, then it can be expected that both β_1 and β_2 will take negative signs – implying that life expectancy will tend to decrease as income inequality increases.

Variables such as LE and Gini can tend to exhibit trending behaviour, therefore it can be expected that both LE and Gini are non-stationary integrated processes.

The model also incorporates a control variable that captures health care spending per capita in order to control for varying levels of access to health care. A priori, it is also expected that healthcare expenditure per capita evolves steadily and in a relatively stable manner over time, thereby making it suitable to be used as a control variable to control for cross country heterogeneity in access to healthcare. Based on the points already outlined in the literature review section of this study, it would be reasonable to expect that healthcare expenditure would influence life expectancy positively, thereby resulting in the coefficient β_3 taking a positive sign.

Furthermore, the model also constitutes a control variable that captures education attainment in terms of the average number of years spent in formal education. A priori it can be expected that this variable should be relatively stable in nature as whilst education attainment grew significantly in the latter half of the 20th century, it may seem to have plateaued for some nations after the turn of the millennium. Due to the arguments and evidence outlined in the literature review section of this study, it would be reasonable to expect that the attainment of education, particularly in excess of a critical number of years in formal education, would positively impact life expectancy. A priori, the coefficient of the education attainment variable β_4 can thereby be expected to take a positive sign.

Standard Estimation Methods for Panel Data Models

Pooled OLS

It is possible to estimate a panel data model via the methodology of Pooled Ordinary Least Squares (OLS) regression, which is occasionally also referred to as the constant coefficients methodology. Essentially, Pooled OLS estimation applies the usual OLS technique in a manner that pools or aggregates all the cross sections that make up the panel data sample. Naturally, the validity of the Pooled OLS technique is subject to the usual Gauss-Markov assumptions.

While the relative simplicity of the Pooled OLS technique can, at first glance, make it relatively appealing for use in research, estimates obtained via Pooled OLS can be extremely unreliable due to the problem of Unobserved Heterogeneity which is explained hereunder. As will be explained in detail, it is for this reason that other techniques are deemed to be more reliable than Pooled OLS in panel data model estimation.

Unobserved Heterogeneity

One of the main issues that relates to the use of panel data is that of the Unobserved Heterogeneity that results from the significant variation in the underlying characteristics of the countries under study. Essentially, the different features and traits specific to each country may contribute significantly to the data obtained for that specific country, in manner that cannot be captured robustly by the model. Such variation in characteristics would most likely relate to geographic, climatic as well as more subtle socio-economy qualities that are harder to pin down and quantify.

This unobserved effect is thereby pushed into the error term of the model, creating a situation akin to that of omitted variable bias. In this instance, the error term of the model does not merely constitute stochastic shocks to the model estimation (the idiosyncratic component) but also constitutes the effects of this inter-country variation (the unobserved heterogeneity component). This is particularly problematic as this would result in the error term being correlated with at least one of the explanatory variables in the model, thereby violating the assumption of exogeneity.

It is possible to deal with the issue of Unobserved Heterogeneity via techniques that transform the model in a manner that captures the underlying features of the model that do not vary with time. If it can be confidently assumed that the individual heterogeneities between countries are constant over time, then this approach would eliminate the omitted variable bias arising from the Unobserved Heterogeneity.

The transformation techniques usually employed in this regard are those of the Fixed Effects (FE) Estimator and the Random Effects (RE) Estimator.

The Fixed Effects Estimator

The Fixed Effects Estimator (FE) involves the use of within transformation to transform the model in a manner that eliminates the time invariant components of the model. A key mechanical aspect of this technique is that the error term of the model could be thought of as being comprised of the two components mentioned earlier, namely; the time variant idiosyncratic error component, which represents the stochastic shocks to the model, and unobserved heterogeneity component (that is the result of the unobserved heterogeneity problem) that would usually be fixed in a dynamic sense if the sample spans only a few units of time. The nature of the unobserved heterogeneity component therefore makes it reasonable to assume that it is time-invariant. Therefore, the FE estimator focuses on the notion that the underlying heterogeneity varies throughout the cross section (between the units under observation) but not through time, so that it is relatively static.

Since the individual unobserved heterogeneity element is assumed to be constant over time, then this within transformation of the FE estimator would eliminate it from the model, thereby solving the endogeneity issue arising from the correlation of the afore mentioned error term and at least one explanatory variable.

The afore mentioned within transformation of the model under FE centres around the process of de-meaning the data via subtraction, which essentially involves transforming the entire model by transforming the individual time-variant terms therein. This occurs by obtaining the statistical mean of each time-invariant variable and thereby subtracting these averages from the actual observed values for each variable in question to yield the transformed variable. This de-meaning process would result in the elimination of any term that does not vary with time thereby eliminating the problematic unobserved heterogeneity component of the error term, thereby solving the Unobserved Heterogeneity Problem. It is worth noting that this de-meaning technique would also result in the elimination of any explanatory variable that is completely time-invariant in nature.

Once this process is completed and the endogeneity problem solved, the transformed model could then be estimated via the Ordinary Least Squares (OLS) Method as long as the idiosyncratic error term does not suffer from heteroscedasticity and is spherical in nature. Therefore, in order to ensure that the estimation technique is indeed robust to possible failures in these assumptions, the model could run instead via Generalised Least Squares (GLS).

The Random Effects Estimator

The FE estimator is to be used when unobserved heterogeneity results in explanatory variables being endogenous due to the correlation of the unobserved heterogeneity error term component with at least one explanatory variable. On the other hand, if there is no such endogeneity present, then Pooled OLS is a valid option for panel data model estimation. However, whilst the use of Pooled OLS may be valid in such an instance, it may not be the optimal technique to use as Pooled OLS may not always yield the most precise estimates possible. In order to obtain the most precise estimates possible, the panel data model may be estimated via the Random Effects (RE) Estimator which is based on the use of a Feasible Generalised Least Squares (FGLS) method. This method is asymptotically more efficient (more efficient as the sample size grows substantially in size) than Pooled OLS.

RE estimation involves applying GLS to a transformed version of the model in question. In a similar fashion to FE, RE involves transforming the variables in the model, with the crucial difference that the RE de-meaning process is based on a quasi-demeaning (or partial demeaning) process. Essentially the statistical mean of each variable in the model is multiplied by a parameter α and the resulting value is subtracted from the actual observed value of each variable to yield the transformed variables that constitute the transformed model.

The parameter α takes a value between 0 and 1. Such that if $\alpha=0$ then RE would be identical to Pooled OLS, whilst if $\alpha=1$ then RE would be mechanically identical to FE. The value for the parameter α is determined, in part, by the regression error variance. Depending on the size of parameter α, the RE estimates obtained may be closer in value to those of FE or Pooled OLS.

The Hausman Test for Endogeneity

A priori, it may be extremely difficult for a researcher to ascertain whether FE or RE is to be used based on the presence (or lack thereof) of endogeneity. It is therefore possible to make an informed decision in this regard through the use of the Hausman Test for endogeneity. As its name implies, the Hausman test determines whether endogeneity is present in the model as is therefore used by researchers as an indicative tool to inform researchers to decide between using FE or RE.

If the Hausman tests indicates the presence of endogeneity then FE is to be used.

If the Hausman tests fails to indicate the presence of endogeneity then RE is to be used.

The Hausman tests determines the presence or absence of endogeneity by ascertaining whether there is a statistically significance difference between the FE and RE coefficient estimates. This is based on the concept that both RE and FE coefficient estimates will be consistent if there is no endogeneity but only FE will be consistent if endogeneity is present. Essentially, if the Hausman test indicates that there is no statistically significant difference between the RE and FE coefficient estimates then there is no endogeneity present and therefore, RE is to be used to estimate the model. On the other hand, if the Hausman test indicates there is indeed a statistically significant difference between the RE and FE coefficient estimates then endogeneity is indeed present and therefore FE is to be used to estimate the model.

The Hausman test can be carried out using a t-test on each coefficient individually or on all the coefficients together jointly via a chi-squared test.

The Model Estimation Process

The avenues of inquiry and investigation around which this study is centred relate to investigating the role that income inequality plays in determining life expectancy in the EU, whilst also investigating the nature of any differences in the income inequality - life expectancy relationship between EU countries. Given these two research motivations, the analytical approach taken in the study involves estimating the conceptual model explained previously in two separate phases.

Firstly, in order to quantitatively investigate the Wilkinson Hypothesis in the EU as a whole, the model is initially estimated using the complete data set for the entirety of the EU. In this manner, it is possible to apply statistical testing to develop an understanding of the roles that both contemporaneous and lagged income inequality play in influencing the life expectancy of the EU population as a whole, whilst simultaneously accounting for health care expenditure per capita and the level of education attainment as control variables.

This is considered as being the initial estimation run of the concept model and will thereby be referred to as **Model 1**.

Secondly, in order to quantitatively investigate how the relationship between income inequality and life expectancy changes between the countries that constitute the EU, a second phase of investigation is undertaken that involves re-arranging the complete data set according to sub-categorizations. The model is then estimated for each one of these smaller data sets.

This sub-categorization is undertaken for two main reasons:

1. It would facilitate a deeper investigation into the underlying mechanisms behind the Wilkinson Hypothesis in the EU and how the income inequality – life expectancy relationship changes drastically between countries and blocs of countries;

2. It facilitates a more detailed quantitative analysis than the estimation of Model 1 as it allows for certain controls or restrictions to be put in place that may not be done adequately through the addition of a control variable. This is due mainly to the difficulty in quantifying certain country characteristics, such as those relating to relative geographic position (where focusing only on one aspect will result in omission bias).

In light of the above, the sub-categorizations are as follows:

- Northern EU countries (**Model 2**);
- Southern EU countries (**Model 3**);
- High GDP countries (**Model 4**);
- Low GDP countries (**Model 5**);
- Countries with a relatively high degree of Ethnic Fractionalisation (**Model 6**);

- Countries with a relatively low degree of Ethnic Fractionalisation (**Model 7**);

With respect to Model 6 and Model 7, Ethnic Fractionalisation refers to the degree of ethnic and cultural homogeneity (scores that tend towards 0) or ethnic and cultural heterogeneity (scores that tend towards 1). In this sense, the countries in model 6 exhibit a relatively high degree of ethnic and cultural diversity in their populations. On the other hand, the countries in model 7 exhibit a relatively low amount of ethnic and cultural diversity in their populations. The concept of ethnic fractionalisation as well as the actual sub-categorizations for EU countries into model 6 and model 7 is based on the acclaimed paper by Alesina et al (2003).

Furthermore, the sub-categorization of countries according to relative GDP per capita is based on the World Economic and Financial Surveys **-** World Economic Outlook Database of the International Monetary Fund.

As explained in a previous section. Each time the model is to be estimated, it will first be estimated via the methodology of Pooled Ordinary Least Squares (OLS). Subsequently, due to the need to re-estimate the model in manner that accounts for country specific heterogeneities, a Hausman Test is used in order to determine whether the Fixed Effects (FE) Estimator or the Random Effects (RE) Estimator provides to optimal solution in this regard. The model is then estimated again via either FE or RE, depending on the outcome of the Hausman Test.

In total this process is undertaken for Model 1 as well as for the sub-categorized models 2-7.

For the sake of completeness and statistical robustness, this estimation process is run for all 7 models with the variables therein being in levels, as well as for all 7 models with the variables therein being taken as logs.

The point of running the model in both levels and logarithmic form is to assess any reinforcing or contradictory evidence with regard to the Wilkinson Hypothesis that may arise from the normalisation of the variables as it can sometimes be the case that strong statistical economic relationships only emerge when the variables are in logarithmic form.

Analysis is thereby conducted through both statistical testing of each of the estimated models individually but also through the comparison of the various results obtained for each model.

Data

The model estimation is built around 15 years of annual data for each EU member state.

Description of Variables

Variable	Description	Source
Life Expectancy at birth (LE)	Life Expectancy at birth can be described as being the average number of years that a new-born human can be expected to live from the point of birth up to the point of natural death, given the environment of mortality conditions and factors that face the person born in a specific country. This variable relates to the value for LE observed at time t	Eurostat
Contemporaneous Gini Coefficient (GINIt)	The Gini coefficient of equivalised disposable income is the standard measure for the level of income inequality in a given population. It is computed as the ratio between the cumulative shares of population equivalised disposable income to the cumulative share of equivalised total disposable income received by the same population over the exact same period of time. This variable relates to the observation for the Gini Coefficient of a particular country observed at time t	Eurostat
Lagged Gini Coefficient (Ginit1)	The Gini coefficient of equivalised disposable income is the standard measure for the level of income inequality in a given population. It is computed as the ratio between the cumulative shares of population equivalised disposable income to the cumulative share of equivalised total disposable income received by the same population over the exact same period of time. This variable relates to the observation for the Gini Coefficient of a particular country observed at time t-1	Eurostat
Healthcare Expenditure Per Capita (HEPC)	Health care spending per capita relates to the population average value for recurrent consumption expenditure on healthcare related goods and services financed via government spending, health insurance and out-of-pocket payments. This does not include investment. This variable relates to the observation for HEPC at time t	OECD

Education Attainment in Years (Educ)	The degree of education attainment, as measured the number of years of schooling can be defined as the average number of years that a person in a particular country spends in formal education (primary, secondary and tertiary). This is a common measure for the stock of human capital. This variable relates to the observation for education attainment of a particular country at time t.	Our World in Data

Descriptive Statistics

Variable	Standard Deviation	Minimum Value	Maximum Value	Mean Value
LE	3.1694	70.6	83.5	78.5960
GINIt	3.9099	22.7	40.2	29.8645
Ginit-1	3.9052	22.7	38.9	29.8455
HEPC	1498.036	401.7	7164.7	2784.612
Educ	1.2595	7.2	14.1	11.4058

A Priori Expectations

Variable	Definition	Coefficient/term	Expected Sign	Meaning
ζ	Intercept term	C	Positive	The base natural duration of a human life in a given country before factoring in the effects of the independent variables.
GINIt	Contemporaneous Gini coefficient	β_1	Negative	The measure for contemporaneous income inequality within a population. This can be expected to negatively influence life expectancy in line with the Wilkinson Hypothesis.
Ginit1	Lagged Gini coefficient	β_2	Negative	The measure for income inequality within a population for the year prior to the current time period. This can be expected to negatively influence life expectancy in line with the Wilkinson Hypothesis.
HEPC	Health Care Expenditure per capita	β_3	Positive	The measure of consumption expenditure on healthcare related goods and service. This can be expected to improve or preserve human health, thereby positively influencing life expectancy.
Educ	Education attainment	β_4	Positive	The number of years spent in formal education. Based on the literature this can be expected to positively impact life expectancy.

Testing for stationarity via Panel Unit Root Tests

The Levin-Lin Chu Test

The issue of non-stationarity is an issue that often plagues datasets that constitute a time-series element. Should this problem of non-stationarity be present in a dataset then the statistical testing and analysis may be rendered invalid or problematic. The nature of this potential non-stationarity problem would thereby necessitate researchers to undertake an adequate degree of testing to determine whether the data being used is stationary or otherwise. In this regard, Unit-Root Tests are employed in order to test for the presence of non-stationarity.

In the case of Longitudinal Panel Data, a fairly popular unit-root test employed in the literature is that of the Levin-Lin Chu test which sets up a null hypothesis whereby the data being tested is indeed stationary – meaning that statistical analysis can proceed. Conversely the alternative hypothesis in the Levin-Lin Chu test is that the data being testing is indeed non-stationary in nature, thereby necessitating that the researcher remedies this problem. The attractiveness of the Levin-Lin Chu test to researchers is amplified by the fact that this test is also capable of mitigating the issues that arise from the problematic presence of autocorrelation and the lack of homoscedasticity which are both problems that commonly plague longitudinal panel data sets. Furthermore, this test is also extremely well suited for use in panel data analysis relating to cross-country analysis (Mifsud, 2019). It is for these reasons that this test is employed in this research.

Essentially, the Levin-Lin Chu test builds upon the concept of the Augmented Dickey-Fuller (ADF) test through permitting time and idiosyncratic effects under the assumption that the data in the longitudinal panel data set is characterised by a coefficient that is autoregressive of order 1 (AR 1), Levin et al (2002). The Levin-Lin Chu test employs the Frisch-Waugh Theorem to compile a single linear regression via stacking the individual regressions together with their nuisance variables. The underlying mechanisms of the test proceed to imitate a large sample size for both the time series and panel elements via Monte Carlo simulations in order to approximate a normal distribution.

Issues and limitations and relating to the estimation of the model

Bias arising from small sample size and lack of variation in Gini

While data for the variables studied in this research is readily available for most EU countries over several years, limited data availability for HEPC and Educ for several countries resulted in a smaller sample size than would have otherwise been desired . Whilst issues relating to small sample size bias are almost always to be expected to some degree in research of this kind, due to the heterogeneity in the data availability, small sample size bias could still reduce the overall accuracy of the estimation process due to the sample data set being insufficiently representative of the reality that is being captured by the model. This would be particularly problematic if the values for the Gini coefficient are relatively static or only change at a slow pace over the time period under study. Such a lack of significant variation in the data combined with the small sample size bias could potentially yield estimation results that do not capture the existence of a Wilkinson Hypothesis style relationship between LE and Gini.

The above point is illustrated by the time series plots hereunder, which show how the Gini coefficient, for most countries, does not exhibit much variation over the period of study.

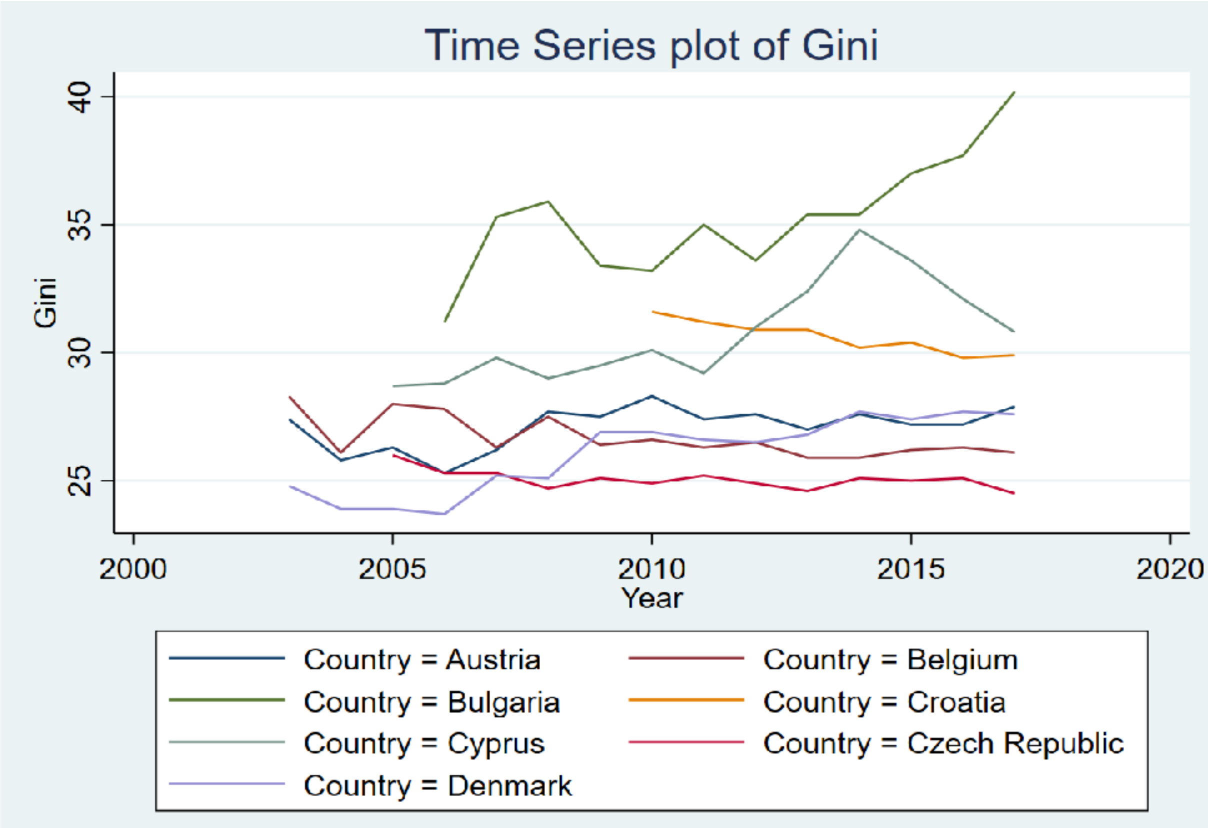

Figure 1 - Overlapping time series plots of the Gini coefficients for the first group of 7 EU member states

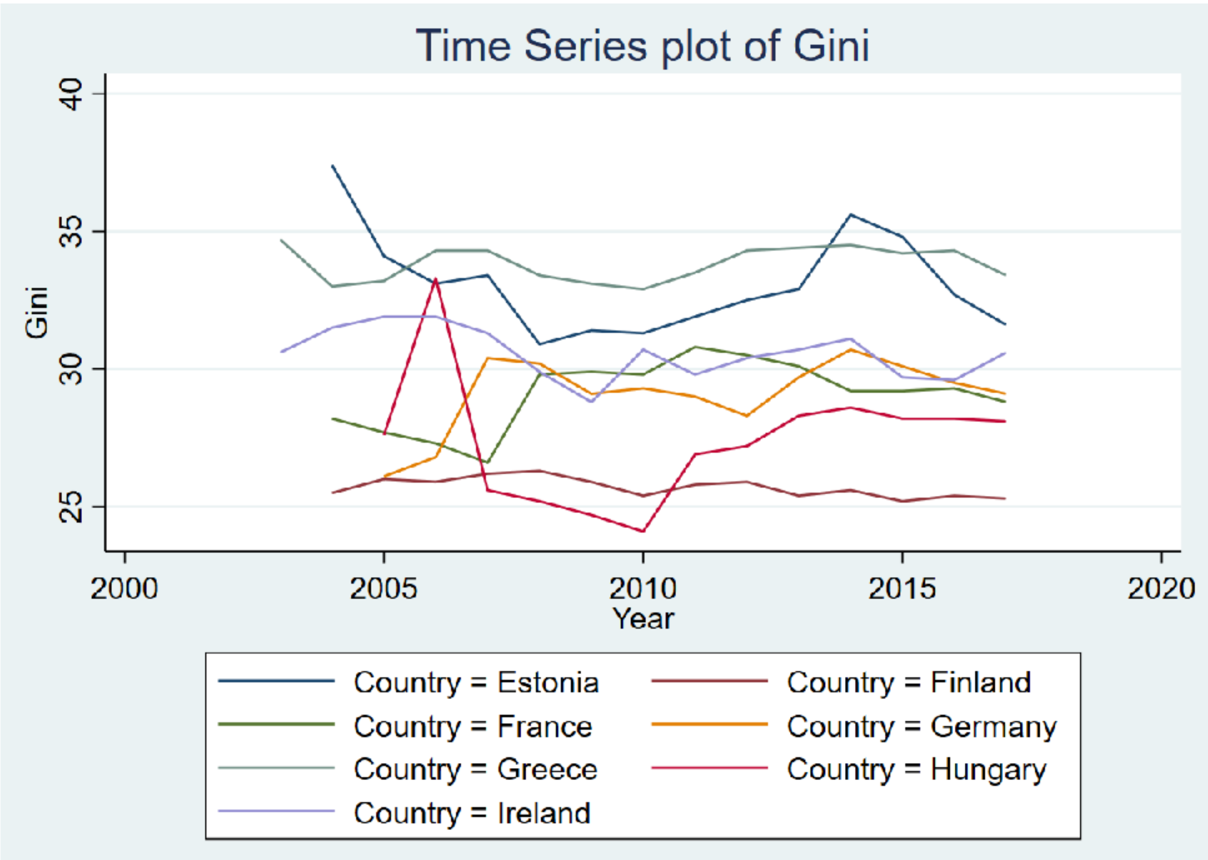

Figure 2 - Overlapping time series plots of the Gini coefficients for the second group of 7 EU member states

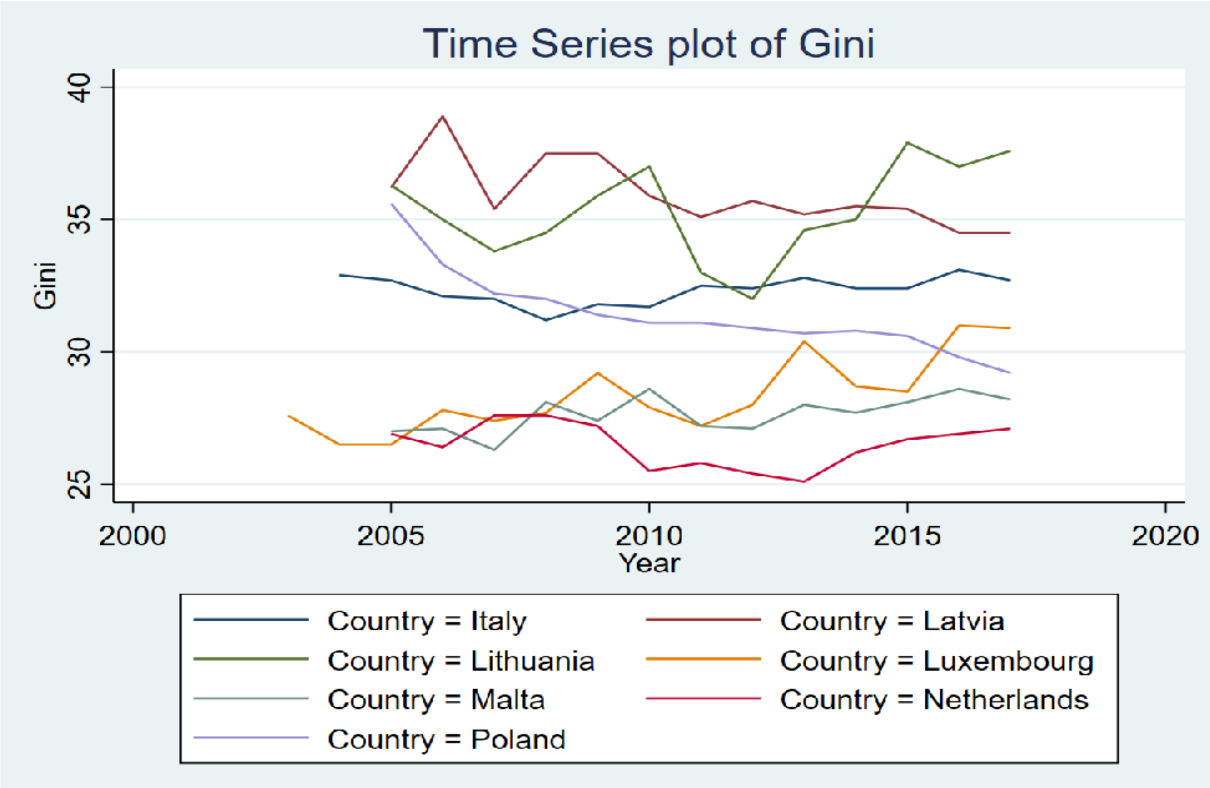

Figure 3 - Overlapping time series plots of the Gini coefficients for the third group of 7 EU member states

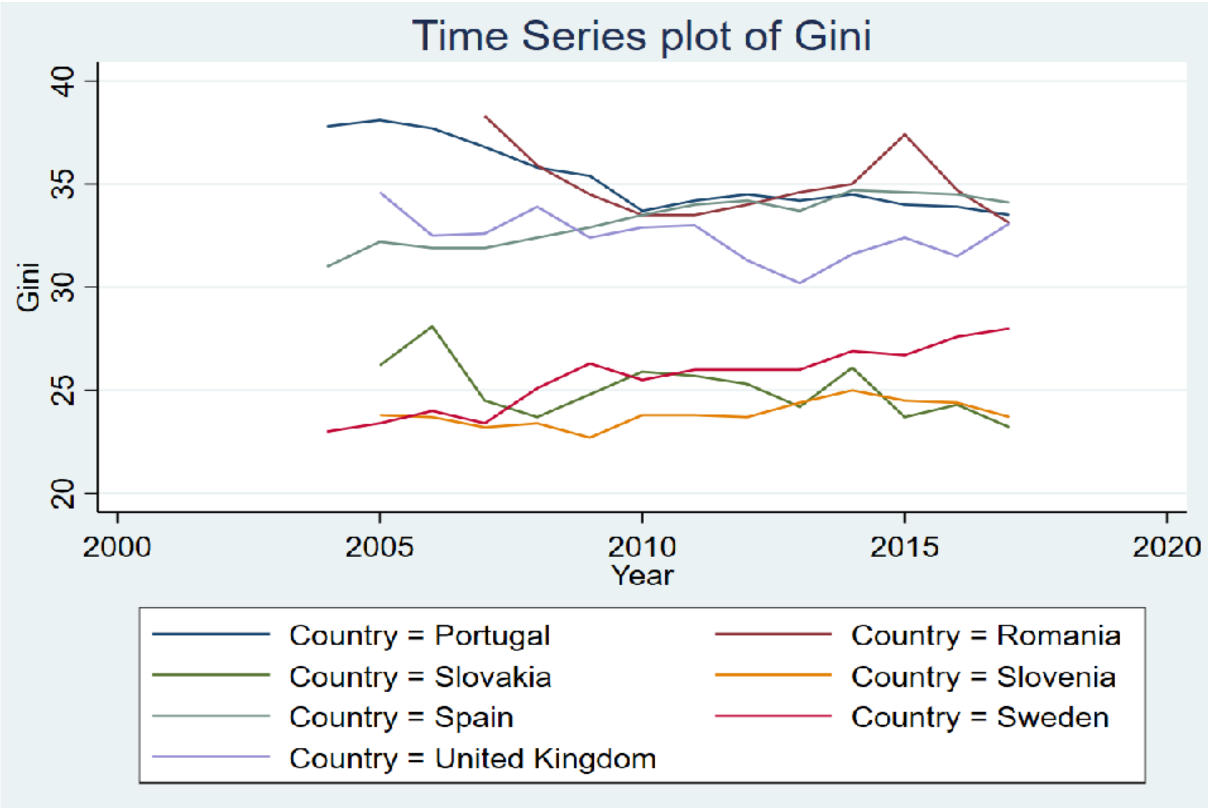

Figure 4 - Overlapping time series plots of the Gini coefficients for the fourth group of 7 EU member states

This lack of variation in the Gini coefficient since the turn of the millennium is emphasised by sources such as Darvas and Wolff (2016). To this end, it may well be the case that the starkly differing growth rates amongst EU countries over the period may be one of the main causes driving this issue (Darvas, 2016; Vandenbroucke et al. 2015).

To further explain the materiality of this problem, analysis of the variation behaviour of the data for the Gini coefficient shows that the Gini does not vary too much about its mean for most countries. As illustrated below, out of the 28 country sample, the Gini coefficient for 20 countries exhibits a maximum variation that is within less than 10% of its mean, whilst for seven of those 28 countries, the Gini coefficient exhibits a maximum variation within less than 5% of its mean. Another potential issue, possibly arising from the poor aforementioned poor growth rates is that for some countries, the Gini coefficient trends upwards over the period whilst life expectancy also rises. Thus, some countries may not be good candidates to support the Wilkinson Hypothesis, even if they show sufficient variation in the Gini coefficient.

The Percentage Variation of the Gini coefficient about its mean - by country

Country	Max variation about the mean (%)	Country	Max variation about the mean (%)
Austria	6.62	Italy	3.51
Belgium	6.07	Latvia	8.22
Bulgaria	13.96	Lithuania	9.49
Croatia	3.23	Luxembourg	9.33
Cyprus	13.16	Malta	4.87
Czech Republic	3.78	Netherlands	5.26
Denmark	9.01	Poland	13.24
Estonia	12.94	Portugal	7.95
Finland	2.33	Romania	9.57
France	8.55	Slovakia	12.16
Germany	10.31	Slovenia	4.84
Greece	2.76	Spain	6.79
Hungary	21.60	Sweden	10.03
Ireland	5.78	United Kingdom	6.97

Omitted Variable Bias

The real-world determinants of human life expectancy are certainly vast and complex and dynamic in nature. Even when narrowed down to modelling life expectancy from the point of view of income inequality and socio-economic control variables, it is still notoriously difficult to capture all of the influencing factors that influence life expectancy. Therefore, any conceptual model devised for the purpose of research would be lacking some non-insignificant degree of explanatory power in describing precisely how life expectancy is affected by socio-economic conditions.

Furthermore, it is also impractical to try to remedy this problem by employing a strategy of adding all of the control variables that are imaginable or remotely economically justifiable as this would be both impractical and absurd from an econometric and analysis perspective. The optimal strategy is therefore to settle upon a model that has enough explanatory power (owing to both theory and the weight of research already done in the literature) whilst minimizing undue awkwardness in the model specification.

Education Attainment as a catchall variable

Whilst it is common for research in the literature to include education attainment (in terms of years spent in education) as a control variable, it is important to note that the inclusion of this variable is usual justified by the argument that increased education attainment would not only correlate with increased life expectancy but would likely have a causation in the achievement of a longer life. This is usually explained through socio-economic avenues such as better employment conditions, higher wages, habitation in residential areas less exposed to pollution, a higher propensity to make better lifestyle choices etc. It is for this reason, that from the point of view of investigating the Wilkinson Hypothesis, the Education Attainment variable acts as a representation of numerous other highly specific variables that affect life expectancy and are commonly derived from education. It is for this reason, that any estimation and subsequent analysis must treat the Education Attainment variable as being multifaceted and less specific in its effects than other variables such as the Gini Coefficient of Health Care expenditure.

Second line of investigation

Due to the short length of the panel data set and the aforementioned issues arising from the small sample size, this dissertation contains a second line of investigation. The scope of this is to overcome the problems relating to estimation inaccuracies that may arise due to the small sample size, particularly so with regard to the contemporaneous Gini coefficient.

Essentially, the main motivation behind this additional layer of investigation is the concern that the Fixed Effects panel data estimation may not yield results that support the Wilkinson Hypothesis in the EU, purely because of the limited size of the panel data set due to several countries missing data for HEPC and Educ.

In order to overcome this problem, this second line of investigation focuses on the variables LE and $GINI_t$ (the contemporaneous Gini coefficient) and collecting and assembling data for these two variables for the longest period possible given the standards and sources used for the main line of investigation (starting at the year 2000). A separate data set will be prepared for each of the 28 EU countries with OLS regression analysis being undertaken for each country. The results yielded will then be used to supplement those of the main line of investigation. Any promising results in this regard will result in the construction of yet another panel data set aggregating data on only LE and Gini for the countries that show promising results under OLS to try and narrow down the potential existence of a negative relationship between income inequality and life expectancy in the EU. This final panel data set would be estimated via both Pooled OLS, and the more reliable Fixed Effects estimation.

CHAPTER 4

EMPIRICAL ANALYSIS AND RESULTS

In this section, the seven models outlined in the previous sections are estimated in order to facilitate this study's empirical analysis of the relationship between income inequality and life expectancy within the EU. The estimation and analysis of these seven models facilitates not only an investigation into the Wilkinson Hypothesis within the EU, but also allows for the attainment of a more comprehensive understanding of how this relationship varies between sub-groups of EU countries due to specific underlying qualities within these groups. It is worth noting that for all seven models, estimated both in levels and in logs, the Hausman test indicates that the Fixed Effects Estimator is the optimal method for dealing with the heterogeneity issues that render Pooled OLS estimation results unreliable.

Stationarity Testing via the Levin-Lin-Chu test

The Levin-Lin-Chu test proposes the null hypothesis that the panels under examination contain unit roots against the alternate hypothesis that the panels under examination are stationary in nature. The key outcome of the test is the value of the bias adjusted t-statistic. If the value of this bias adjusted t-statistic suggests statistical significance then the null hypothesis is rejected. On the other hand, if the value of the bias adjusted t-statistic does not imply statistical significance then the null hypothesis is not rejected.

Since the Levin-Lin-Chu test can only be applied to strongly balanced panel data, it was not applicable to some of the variables in the large but not completely balanced data set. In order to solve this problem, the data set was rearranged and shortened until it was completely balanced. The Levin-Lin-Chu test was thereby applied to variables in this panel data set.

The results, as outlined in the table in the annex, indicate that the null hypothesis should be rejected for each variable examined. This therefore implies that all the variables in model are stationary in nature.

Model Estimation

This subsection presents and explains the estimation results for the models, whilst the results are outlined in the relevant tables for each model.

Model 1- The relationship between income inequality and life expectancy for the EU as a whole

The model described in previous sections of this study and referred to as Model 1 is estimated initially via Pooled OLS and then via Fixed Effects with the results presented in table [1].

Model 1 estimation via Pooled OLS

When analysing the Pooled OLS results in both levels and logs, the results were not in line with a priori expectations. The base natural duration of a human life of 85 is relatively high. Furthermore, there seems to be no apparent relationship between contemporaneous and lagged income inequality and life expectancy as HEPC and Educ are the only independent variables to be statistically significant. The results indicate that an increase in annual HEPC of Eur 1000 would be associated with an average increase in life expectancy of 1.2 years ceteris paribus. On the other hand, increased education attainment could be associated with deterioration in life expectancy. Since these results are obtained via Pooled OLS, the underlying imperfections of the methodology could yield misleading results, especially when compared to fixed effects.

Model 1 estimation via Fixed Effects

When estimated via the more reliable Fixed Effects (FE), the results obtained for the Model 1 estimation in both levels and logs are much more in line with a priori expectations than the results obtained via Pooled OLS. To begin with, the base natural duration of a human life is estimated to be 59 years, a value that leaves ample room for the effects of the independent variables to impact life expectancy positively. The results do not support the existence of any statistically significant relationship between life expectancy and contemporaneous or lagged income inequality as both of these are found to be statistically insignificant. On the other hand, both HEPC and Educ were found to be statistically significant. This is manifested in the finding that an increase in per annum HEPC can be associated with an increase in life expectancy of

0.5 years, ceteris paribus, whilst an additional year of education attainment may be associated with an increase in life expectancy of 1.5 years on average, ceteris paribus.

Prioritising the FE results would thereby indicate that the Wilkinson Hypothesis does not seem to hold in the EU as a whole whilst HEPC and Educ are key determinants of Life Expectancy.

MODEL 1

Pooled OLS

Dependent Variable: LE

	Constant	**GINIt**	**Ginit-1**	**HEPC**	**Educ**
levels					
R-Squared: 0.5502					
Coefficient	85.0635	0.0500	-0.0689	0.0012	-0.7402
t-stat	51.92	0.57	-0.78	17.06	-8.36
Sd error	1.6384	0.0879	0.0886	0.00007	0.0885

	Constant	**lnGINIt**	**lnGinit-1**	**lnHEPC**	**lnEduc**
logs					
R-Squared: 0.6511					
Coefficient	4.1546	0.0392	-0.0189	0.0415	-0.0704
t-stat	70.59	1.33	-0.63	21.60	-6.47
Sd error	0.0589	0.0295	0.0298	0.0019	0.0109

Fixed Effects Estimator

Dependent Variable: LE

	Constant	**GINIt**	**Ginit-1**	**HEPC**	**Educ**
levels					
R-Squared (within): 0.5404					
Coefficient	59.3092	0.0373	0.0065	0.0005	1.5009
t-stat	38.37	0.98	0.18	7.07	14.22
Sd error	1.5456	0.0379	0.0367	0.00007	0.1056

	Constant	**lnGINIt**	**lnGinit-1**	**lnHEPC**	**lnEduc**
logs					
R-Squared (within): 0.4925					
Coefficient	3.6046	0.0243	0.0108	0.0160	0.2160
t-stat	57.66	1.62	0.74	4.99	14.64
Sd error	0.0625	0.0150	0.0146	0.0032	0.0148

Table 1 –Estimation results for Model 1

Model 2- The relationship between income inequality and life expectancy for Northern EU countries

The model described previously described as Model 2, focuses only on Northern EU countries and is estimated initially via Pooled OLS and then via Fixed Effects with the results presented in table [2].

Model 2 estimation via Pooled OLS

When analysing the Pooled OLS results in both levels and logs, the estimation results do not meet a priori expectations as they fail to evidence the Wilkinson Hypothesis in Northern EU countries as both contemporaneous and lagged income inequality are statistically insignificant. Educ is also found to be statistically insignificant. The base natural duration of a human life of around 78 years is relatively high although still not too far out of line with the literature and expectations. The main result obtained from the Pooled OLS is that an increase in per annum HEPC of Eur 1000 could be associated with an increase in life expectancy of 1.3 years.

Model 2 estimation via Fixed Effects

The relatively more reliable FE estimations yield results that do not evidence the Wilkinson Hypothesis in Northern EU countries as both contemporaneous and lagged income inequality are found to be statistically insignificant, with the base natural duration of a human life of around 64 years is understandable and not too far off from the value found for the EU as a whole.

On the other hand, both HEPC and Educ are found to be statistically significant such that an increase in annual HEPC of Eur 1000 can be associated with an increase in average life expectancy of 0.7 years, ceteris paribus, whilst increasing education attainment by one year can be associated with an increase in average life expectancy of 1.15 years, ceteris paribus.

Prioritising the FE results would thereby indicate that the Wilkinson Hypothesis does not seem to hold in the Northern EU countries whilst HEPC and Educ are key determinants of Life Expectancy.

MODEL 2 – Northern Countries

Pooled OLS

Dependent Variable: LE					
	Constant	**GINIt**	**Ginit-1**	**HEPC**	**Educ**
levels					
R-Squared: 0.7353					
Coefficient	77.8382	0.0335	-0.1102	0.0013	-0.0466
t-stat	40.06	0.37	-1.22	19.24	-0.31
Sd error	1.9429	0.0914	0.0901	0.00007	0.1507

	Constant	**lnGINIt**	**lnGinit-1**	**lnHEPC**	**lnEduc**
logs					
R-Squared: 0.8048					
Coefficient	3.9463	0.0162	-0.0183	0.0470	0.0239
t-stat	62.05	0.55	-0.63	24.03	1.22
Sd error	0.0636	0.0293	0.0291	0/0020	0.0195

Fixed Effects Estimator

Dependent Variable: LE					
	Constant	**GINIt**	**Ginit-1**	**HEPC**	**Educ**
levels					
R-Squared (within): 0.5550					
Coefficient	63.5994	0.0406	-0.0456	0.0007	1.1487
t-stat	30.04	0.72	-1.02	7.83	8.01
Sd error	2.1172	0.0560	0.0534	0.00009	0.1435

	Constant	**lnGINIt**	**lnGinit-1**	**lnHEPC**	**lnEduc**
logs					
R-Squared (within): 0.5053					
Coefficient	3.6786	0.0146	-0.0090	0.0295	0.1771
t-stat	45.03	0.67	-0.43	6.64	8.19
Sd error	0.0817	0.0218	0.0211	0.0044	0.0216

Table 2 - Estimation results for Model 2

Model 3- The relationship between income inequality and life expectancy for Southern EU countries

The model described in previous sections of this study and referred to as Model 3 is estimated initially via Pooled OLS and then via Fixed Effects with the results presented in table [3].

Model 3 estimation via Pooled OLS

The Pooled OLS estimation results for both the levels and log models do not offer support for the Wilkinson Hypothesis in Southern EU countries as both contemporaneous and lagged income inequality are statistically insignificant, whilst the base natural duration of a human life of around 60 years is a very appropriate value, given the literature. On the other hand, both HEPC and Educ are found to be statistically significant such that an increase in annual HEPC of EUR 1000 can be associated with an increase in average life expectancy of 3.4 years, ceteris paribus. Similarly, increasing education attainment by one year can be associated with an increase in life expectancy of 0.67 years, ceteris paribus.

Model 3 estimation via Fixed Effects

The FE estimation results also do not support the existence of the Wilkinson Hypothesis in Southern EU countries as both contemporaneous and lagged income inequality are found to be statistically insignificant, with HEPC also being found to be statistically insignificant. The estimation yielded a base natural duration of a human life of around 59 years, which is the same as the value estimated via Pooled OLS. In keeping with the trend for the FE estimations, Educ is both statistically significant and extremely influential, such that an increase in education attainment of one year can be associated with an increase in average life expectancy of 1.74 years, ceteris paribus.

MODEL 3 – Southern Countries

Pooled OLS

Dependent Variable: LE

	Constant	GINIt	Ginit-1	HEPC	Educ
levels					
R-Squared: 0.6589					
Coefficient	59.6838	0.0545	0.1450	0.0034	0.6686
t-stat	13.11	0.42	1.05	12.43	2.86
Sd error	4.5515	0.1312	0.1395	0.0003	0.2339

	Constant	lnGINIt	lnGinit-1	lnHEPC	lnEduc
logs					
R-Squared: 0.7236					
Coefficient	3.2537	0.0593	0.0532	0.0886	0.1015
t-stat	21.60	1.28	1.11	14.96	3.92
Sd error	0.1507	0.0464	0.0481	0.0045	0.0259

Fixed Effects Estimator

Dependent Variable: LE

	Constant	GINIt	Ginit-1	HEPC	Educ
levels					
R-Squared (within): 0.6435					
Coefficient	59.1276	0.0344	0.0450	-0.0003	1.7462
t-stat	25.77	0.78	1.01	-1.38	11.69
Sd error	2.2945	0.0442	0.0445	0.0002	0.1494

	Constant	lnGINIt	lnGinit-1	lnHEPC	lnEduc
logs					
R-Squared (within): 0.6610					
Coefficient	3.7914	0.0250	0.0218	-0.0082	0.2062
t-stat	41.56	1.49	1.31	-1.91	11.72
Sd error	0.0912	0.0167	0.0167	0.0043	0.0176

Table 3 - Estimation results for Model 3

Model 4 - The relationship between income inequality and life expectancy for High GDP EU countries

The model described in previous sections of this study and referred to as Model 4 is estimated initially via Pooled OLS and then via Fixed Effects with the results presented in table [4].

Model 4 estimation via Pooled OLS

The Pooled OLS estimations in both levels and logs for model 4 yield results that do not support the Wilkinson Hypothesis as both the contemporaneous and lagged income inequality are found to be statistically insignificant. The base natural duration of a human life of around 81 years is somewhat higher than expected.

On the other hand, both HEPC and Educ are found to be statistically significant such that an increase in annual HEPC of EUR 1000 can be associated with an increase in average life expectancy of 0.4 years, ceteris paribus. Counterintuitively, an increase in education attainment of one year can be associated with a deterioration in life expectancy of just under 0.5 years, ceteris paribus. This latter result may have arisen due to the problems relating to the Pooled OLS technique.

Model 4 estimation via Fixed Effects

The FE estimation results for both the levels and log models do not support the Wilkinson Hypothesis in high GDP EU countries as contemporaneous income inequality is found to be statistically insignificant whilst lagged income inequality is found to be statistically significant, taking the unexpected positive sign, The nature of the influence of lagged income inequality is such that an increase in the Gini coefficient of one unit can be associated with an increase in life expectancy of 0.09 years, ceteris paribus.

Furthermore, both HEPC and Educ are found to be statistically significant such that an increase in annual HEPC of EUR 1000 can be associated with an increase in average life expectancy of around 0.8 years, ceteris paribus. Similarly, an increase in education attainment of one year can be associated with an increase in average life expectancy of 0.9 years, ceteris paribus.

MODEL 4 – High GDP Countries

Pooled OLS

Dependent Variable: LE

	Constant	**GINIt**	**Ginit-1**	**HEPC**	**Educ**
levels					
R-Squared: 0.3483					
Coefficient	80.3709	0.1189	0.0342	0.0004	-0.4652
t-stat	59.32	1.41	0.41	4.86	-6.19
Sd error	1.3549	0.0844	0.0841	0.00008	0.0752

	Constant	**lnGINIt**	**lnGinit-1**	**lnHEPC**	**lnEduc**
logs					
R-Squared: 0.3214					
Coefficient	4.2278	0.0424	0.0096	0.0183	-0.0651
t-stat	74.35	1.39	0.32	4.29	-5.81
Sd error	0.0569	0.0304	0.0303	0.0043	0.0112

Fixed Effects Estimator

Dependent Variable: LE

	Constant	**GINIt**	**Ginit-1**	**HEPC**	**Educ**
levels					
R-Squared (within): 0.7265					
Coefficient	63.3866	0.0591	0.0931	0.0008	0.8727
t-stat	40.50	1.23	2.07	11.98	7.52
Sd error	1.5652	0.0480	0.0450	0.00006	0.1160

	Constant	**lnGINIt**	**lnGinit-1**	**lnHEPC**	**lnEduc**
logs					
R-Squared (within): 0.7473					
Coefficient	3.5962	0.0184	0.0348	0.0420	0.1111
t-stat	70.32	1.13	2.28	13.04	7.28
Sd error	0.0511	0.0162	0.0153	0.0032	0.0153

Table 4 - Estimation results for Model 4

Model 5 - The relationship between income inequality and life expectancy for Low GDP EU countries

The model described in previous sections of this study and referred to as Model 5 is estimated initially via Pooled OLS and then via Fixed Effects with the results presented in table [5].

Model 5 estimation via Pooled OLS

The Pooled OLS estimations in both levels and logs for model 5 yield results that not support the Wilkinson Hypothesis in low GDP EU countries as both contemporaneous and lagged income inequality are found to be statistically insignificant. Education attainment is also found to be statistically significant.

The base natural duration of a human life of 73 years is relatively high given the literature. The impact of HEPC on life expectancy is such that an increase in annual HEPC of EUR 1000 can be associated with an increase in average life expectancy of 2.9 years, ceteris paribus.

Model 5 estimation via Fixed Effects

The FE estimations in both levels and logs for model 5 yield results that do not support the Wilkinson Hypothesis in low GDP EU countries as both contemporaneous and lagged income inequality are found to be statistically insignificant. HEPC is also not found to be statistically significant. The base natural duration of a human life of 60 is very much in line with expectations and is also consistent with the values obtained in other FE estimations. The impact of the statistically significant education attainment on life expectancy is such that an increase in education attainment of one year can be associated with an increase in average life expectancy of 1.65 year, ceteris paribus.

MODEL 5 – Low GDP Countries

Pooled OLS

Dependent Variable: LE

	Constant	**GINIt**	**Ginit-1**	**HEPC**	**Educ**
levels					
R-Squared: 0.4746					
Coefficient	73.0057	0.1004	-0.0630	0.0029	-0.0786
t-stat	20.46	0.83	-0.51	8.08	-0.43
Sd error	3.5682	0.1211	0.1225	0.0004	0.1840

	Constant	**lnGINIt**	**lnGinit-1**	**lnHEPC**	**lnEduc**
logs					
R-Squared: 0.4967					
Coefficient	3.9634	0.0535	-0.0298	0.0502	-0.0231
t-stat	29.15	1.14	-0.63	8.57	-1.01
Sd error	0.1360	0.0468	0.0472	0.0059	0.0229

Fixed Effects Estimator

Dependent Variable: LE

	Constant	**GINIt**	**Ginit-1**	**HEPC**	**Educ**
levels					
R-Squared (within): 0.4954					
Coefficient	60.2320	0.0212	-0.0578	-0.0003	1.6546
t-stat	18.93	0.40	-1.10	-1.26	8.42
Sd error	3.1817	0.0524	0.0527	0.0003	0.1966

	Constant	**lnGINIt**	**lnGinit-1**	**lnHEPC**	**lnEduc**
logs					
R-Squared (within): 0.4599					
Coefficient	3.8241	0.0212	-0.0166	-0.0046	0.2236
t-stat	27.61	0.98	-0.76	-0.76	8.20
Sd error	0.1385	0.0217	0.0219	0.0060	0.0273

Table 5 - Estimation results for Model 5

Model 6 - The relationship between income inequality and life expectancy for High Ethnic Fractionalization EU countries

The model described in previous sections of this study and referred to as Model 6 is estimated initially via Pooled OLS and then via Fixed Effects with the results presented in table [6].

Model 6 estimation via Pooled OLS

The Pooled OLS estimations in both levels and logs for model 6 yield results that do not support the Wilkinson Hypothesis in EU countries with high ethnic fractionalisation as both contemporaneous and lagged income inequality are found to be statistically insignificant. The base natural duration of a human life of 88.5 years is extremely high and not in line with expectations.

Both HEPC and Educ are found to be statistically significant such that an increase in annual HEPC of EUR 1000 can be associated with an increase in average life expectancy of 1.2 years, ceteris paribus. On the other hand, interestingly enough, an increase in education attainment of one year can be associated with a decrease in average life expectancy of 0.9 years, ceteris paribus. The latter result may have arisen due to the shortcomings of the Pooled OLS methodology.

Model 6 estimation via Fixed Effects

The FE estimations in both levels and logs for model 6 yield results that do not support the Wilkinson Hypothesis in EU countries with a high degree of ethnic fractionalisation as both contemporaneous and lagged income inequality are found to be statistically insignificant.

The base natural duration of a human life of 53 is in line with other FE estimations and leaves ample room for the independent variables to positively impact life expectancy. The influence of the statistically significant HEPC and Educ are such that an increase in annual HEPC of EUR 1000 can be associated with an increase in average life expectancy of 0.4 years, ceteris paribus. Similarly, an increase in education attainment of one year can be associated with an increase in average life expectancy of 2.08 years, ceteris paribus.

MODEL 6 – High Ethnic Fractionalization Countries

Pooled OLS

Dependent Variable: LE

	Constant	GINIt	Ginit-1	HEPC	Educ
levels					
R-Squared: 0.6146					
Coefficient	88.5612	0.0170	-0.1003	0.0012	-0.8921
t-stat	42.10	0.14	-0.80	12.30	-7.15
Sd error	2.1034	0.1223	0.1254	0.0001	0.1248

	Constant	lnGINIt	lnGinit-1	lnHEPC	lnEduc
logs					
R-Squared: 0.7053					
Coefficient	4.3354	0.0265	-0.0284	0.0391	-0.1056
t-stat	56.14	0.63	-0.66	15.38	-6.57
Sd error	0.0772	0.0418	0.0430	0.0025	0.0162

Fixed Effects Estimator

Dependent Variable: LE

	Constant	GINIt	Ginit-1	HEPC	Educ
levels					
R-Squared (within): 0.5414					
Coefficient	53.1862	0.0103	-0.0068	0.0004	2.0838
t-stat	22.27	0.17	-0.12	2.79	11.17
Sd error	2.3879	0.0613	0.0578	0.0001	0.1866

	Constant	lnGINIt	lnGinit-1	lnHEPC	lnEduc
logs					
R-Squared (within): 0.5233					
Coefficient	3.4870	0.0095	-0.0007	0.0113	0.3100
t-stat	34.34	0.39	-0.03	2.26	11.36
Sd error	0.1015	0.0244	0.0231	0.0050	0.0272

Table 6 - Estimation results for Model 6

Model 7 - The relationship between income inequality and life expectancy for Low Ethnic Fractionalization EU countries

The model described in previous sections of this study and referred to as Model 7 is estimated initially via Pooled OLS and then via Fixed Effects with the results presented in table [7].

Model 7 estimation via Pooled OLS

The Pooled OLS estimations in both levels and logs for model 7 yield results that do not support the Wilkinson Hypothesis in EU countries with a low degree of ethnic fractionalisation as both contemporaneous and lagged income inequality are found to be statistically insignificant. Education attainment is also found to be statistically insignificant.

The base natural duration of a human life of 75 years is relatively high, given the literature and other estimated results. At this point it is worth noting that the intercept term estimated via Pooled OLS tends to be significantly higher than the intercept value obtained via FE estimation.

The influence of the statistically significant HEPC on life expectancy is such that an increase in annual HEPC of EUR 1000 can be associated with an increase in average life expectancy of 0.9 years, ceteris paribus.

Model 7 estimation via Fixed Effects

The FE estimations in both levels and logs for model 7 yield results that do not support the Wilkinson Hypothesis in EU countries with a low degree of ethnic fractionalisation as both contemporaneous and lagged income inequality are found to be statistically insignificant.

The base natural duration of a human life of 66 years is very much in line with expectations and is also consistent with the values obtained in other FE estimations, although slightly on the high side.

The influence of the statistically significant HEPC and Educ are such that an increase in annual HEPC of EUR 1000 can be associated with an increase in average life expectancy of 0.7 years, ceteris paribus, whilst an increase in education attainment of one year can be associated with an increase in average life expectancy of 1.07 years, ceteris paribus.

MODEL 7 – Low Ethnic Fractionalization Countries

Pooled OLS

Dependent Variable: LE

	Constant	GINIt	Ginit-1	HEPC	Educ
levels					
R-Squared: 0.3448					
Coefficient	74.8072	0.1685	0.0073	0.0009	-0.2364
t-stat	28.72	1.44	0.06	8.31	-1.80
Sd error	2.6048	0.1171	0.1150	0.0001	0.1311

	Constant	lnGINIt	lnGinit-1	lnHEPC	lnEduc
logs					
R-Squared: 0.4359					
Coefficient	3.8931	0.0688	0.0019	0.0377	-0.0193
t-stat	42.97	1.71	0.05	10.10	-1.22
Sd error	0.0906	0.0403	0.0396	0.0037	0.0158

Fixed Effects Estimator

Dependent Variable: LE

	Constant	GINIt	Ginit-1	HEPC	Educ
levels					
R-Squared (within): 0.6338					
Coefficient	65.6982	0.0181	-0.0137	0.0007	1.0732
t-stat	36.20	0.42	-0.33	8.70	9.40
Sd error	1.8149	0.0426	0.0420	0.0008	0.1142

	Constant	lnGINIt	lnGinit-1	lnHEPC	lnEduc
logs					
R-Squared (within): 0.5617					
Coefficient	3.7068	0.0236	0.0071	0.0225	0.1629
t-stat	52.95	1.40	0.42	6.07	10.45
Sd error	0.07	0.0169	0.0168	0.0037	0.0156

Table 7 - Estimation results for Model 7

Evidence for the Wilkinson Hypothesis in the EU via initial investigation

Overall, the model estimations conducted in this study yield results that do not support the Wilkinson Hypothesis within the EU. Essentially, the results of this study indicate that both lagged and contemporaneous income inequality are not statistically significant in influencing life expectancy. This finding is consistent throughout the seven different models. This therefore implies that, upon initial analysis, there is no material Wilkinson Hypothesis style negative relationship between income inequality and population health outcomes within the EU and that this relationship is robust to variations to the underlying geographic, wealth and ethnic and cultural factors.

This result is particularly interesting when one considers that there is ample evidence in the literature to support the Wilkinson Hypothesis within the United States of America. Such findings would imply that although both the EU and the states therein are relatively similar economically and culturally to the USA, the Wilkinson Hypothesis style negative relationship between income inequality and life expectancy would appear to break down in the EU.

At this point, it would be prudent to keep in mind the aforementioned limitations of this Panel Data set, particularly those arising from the small size and the relative lack of variation in how the Gini coefficient evolves over the period under study for most of the EU member states. In light of this, such results, and their failure to support the Wilkinson Hypothesis may be the direct result of this issue. Essentially, such a lack of variation in the data for the Gini over the period may render the Panel Data model estimation incapable of capturing any statistically significant negative relationship between life expectancy and income inequality – even if this does exist in reality. It is therefore important that these initial findings are taken in that context.

These findings can thereby be taken to reiterate the concerns that the behaviour in the Gini coefficient for EU countries since the turn of the millennium is just one of the many symptoms of the lack of economic convergence as well as stagnant growth rates across the EU member states (Darvis, 2016; Darvas and Wolff, 2016; Vandenbroucke et al. 2015). Whilst these phenomena played out most elaborately just prior to the Financial Crisis and the period thereafter, the recent economic turmoil brought about by the COVID-19 Pandemic is likely to have medium to long term effects that may only exacerbate this issue.

The role of Education Attainment

Overall, the model estimations conducted in this study all yield extremely similar results with regard to the potential effect that education attainment (in terms of years spent in formal schooling) may have in influencing life expectancy within the EU. All of the seven models explained and estimated in this study yield results that indicate that education attainment has a significant and extremely strong positive impact on life expectancy within the EU, which is in line with a priori expectations. The smallest impact on life expectancy arising from an increase in education attainment by one year is that of an increase of 0.87 years in the High GDP EU countries group. On the other hand, the largest impact was that of an increase of 2.08 years in the High Ethnic Fractionalization group of EU countries. On an average, the impact was that of an increase in life expectancy of 1.44 years, ceteris paribus.

This strong positive relationship between education attainment and life expectancy remains robust and relatively consistent for all seven variations of the original conceptual model. This may suggest support for the findings and theoretical expectations within the literature that advocate for the existence of a strong and stable mechanical relationship between the attainment of formal education and improvements in life expectancy such that it cannot be 'explained away' by trying to control for key underlying aspects of the population under study (such as variations relating to geography, culture or gross national wealth). Naturally, the strong positive effect that improvements in education attainment has on life expectancy within the EU may be carried through via a myriad of transmission channels, with it being reasonable to expect that chief among them would be channels that directly or indirectly relate to socio-economic mobility and upward shifts in holistic living conditions.

Besides the multiple, highly effective and self-sustaining transmission channels through which education attainment could potentially affect life expectancy, another crucial factor that could play a significant role (from the point of view of the life expectancy – income inequality relationship) is the increased volume of children and young adults in the EU that have furthered their formal education since the turn of the millennium (as would be reflected in education enrolment statistics). Essentially, what this would mean is that as time has progressed and more money has been spent on education within the EU, the beneficial effects of higher levels of education attainment have been enjoyed by a growing proportion of the population – further preserving the strength of the impact that increased education attainment has on population life expectancy.

The findings obtained could thereby suggest that education attainment could serve to be a key and effective socio-economic variable to be targeted by public policy as a means of improving population health outcomes.

The role of Health Care Expenditure per capita

Overall, the findings of this study in this regard are in line with a priori expectations, such that the results yielded by five out of the seven models estimated indicate that Health Care Expenditure per capita (HEPC) has a strong positive influence on life expectancy within the EU. This relationship appears to break down only in the model estimations relating to the group of Southern EU countries and the group of the low GDP countries. The smallest impact attained from the model estimations arising from an increase in annual HEPC of EUR 1000 was that of an increase in life expectancy of 0.4 years for the group of EU countries that exhibit a high degree of ethnic fractionalisation. On the other hand, the biggest attained was that of an increase in life expectancy of 0.8 years for the group of EU countries with relatively high GDP. The impact across the model was that of an average increase in life expectancy of 0.62 years ceteris paribus, .

It is worth keeping in mind that, while significant and strong, the relationship between HEPC and life expectancy may be stronger in other countries outside the EU. Various explanations may exist for this. To begin with the level of HEPC within the EU is relatively high when compared to other, less developed areas of the world. Furthermore, the base natural duration for a human life across EU countries is, once again, relatively high when compared to other less developed parts of the world (even when cross country heterogeneity is taken into account). These two factors, together with the fact that during the period under study medical technology has not made drastic leaps forward, could lead one to question whether there could exist a phenomenon in the EU akin to some kind of diminishing marginal returns to health care expenditure per capita (for the perspective of the life expectancy – income inequality relationship). Such a phenomenon could arise due to EU citizens having achieved a very high life expectancy, and enjoying high per capita spending on health in an environment when healthcare technology may have stagnated.

All things considered, in this model framework, HEPC could be seen as an effective variable to target if a policy maker or government wishes to improve population health outcomes. HEPC could be targeted on its own, or together with population education outcomes to augment the positive effect that education attainment has on life expectancy. Although, the evidence of this study does not support such targeting for the low GDP group and Southern EU countries group.

Analysis of differences between the different models

As already explained, the results yielded by the model estimations do not support the existence of a negative relationship between income inequality and life expectancy in the EU. This finding remains consistent for all of the models.

Overall, the estimation of the seven models (explained in depth in previous sections) in order to control for various underlying aspects of the EU population, has indicated that the impact of education attainment on life expectancy is consistent in nature and does not breakdown due to the geographic, ethnic, cultural and national wealth variations applied to the modelling process.

Whilst the relationship does not breakdown, the influence that the variations in the models have on altering the nature of the relationship between education attainment and life expectancy is quite pronounced in terms of the resulting variations in the magnitude of the impact that education attainment has on life expectancy. To begin with, there is a significant gap between the minimum and maximum impact values obtained (with respect to the increase in life expectancy brought about by increasing education attainment by one year). As already explained, the lowest impact value obtained was that of 0.87 years whilst the highest impact value was that of 2.08 years. This could be interpreted to mean that the underlying transmission channels through which education impacts life expectancy are sensitive to socio-economic factors relating to geography, ethnicity, culture and national wealth.

The model variations impact the relationship between HEPC and life expectancy in a more interesting way. Whilst the model variations do influence the relationship enough for it to breakdown in two cases, this influence may be a lot more subdued in the five other cases. To begin with, there is not a large gap between the minimum and maximum impact attained in terms of increases in life expectancy resulting from increases in HEPC of EUR 1000. The lowest impact value was that of 0.4 years while the highest was that of 0.8 years. Furthermore, the impact value of 0.7 years was obtained in the other three instances.

This could thereby be interpreted to suggest that while not insignificant, the influence that geographic, ethnic, cultural and national wealth factors have on the relationship between HEPC and life expectancy in the EU may be relatively subtle. By extension, this could be taken to mean that the transmission channels through which HEPC impacts life expectancy are stable and mostly immune to social factors represented by the model variations.

Second Line of Investigation

Further Investigation into the Wilkinson Hypothesis in EU countries via country by country OLS regression analysis with longer data sets

The main line of investigation of this dissertation yielded interesting results for the role of HEPC and Educ in playing a key role in influencing life expectancy in the EU but the model estimations did not yield results that could support the Wilkinson Hypothesis within the EU.

The data for HEPC and Educ is relatively limited for most EU countries, therefore certain compromises had to be made in order to build to a panel dataset that could encompass all 28 EU countries (pre-Brexit) as part of the model described in previous chapters of this dissertation. Two of the main compromises made in this regard was that the panel data set covered only fifteen years' worth of data, whilst also being unbalanced in nature due to there being multiple instances of missing data for EU countries for variables such as HEPC and Educ during the period under study.

A second layer of investigation was thereby undertaken out of concern that incorrect conclusions could potentially be drawn about the relationship between income inequality and life expectancy in the EU due to the afore mentioned issues arising in the modelling process.

In order to overcome these difficulties, model estimations were conducted for countries with the most years of data availability for LE and Gini without regard for the inclusion of HEPC and Educ. This estimation process was conducted on a country by country basis via Ordinary Least Squares.

This secondary line of investigation, and the results obtained, support the Wilkinson Hypothesis in 6 out of the 28 EU countries investigated in the original model.

As outlined in the tables 8 to 13 hereunder, estimating models for specific countries over longer time period yielded results that support the existence of a strong negative relationship between income inequality and life expectancy in six EU countries.

Whilst the results of this second layer of investigation only support the Wilkinson Hypothesis in 21.43% of EU countries, it is rather interesting indeed that those 6 countries that do produce results that support the Wilkinson Hypothesis are representative of all of the 6 categorization groups in the main line of investigation, namely; Northern and Southern, low and high GDP as well as low and high ethnic fractionalisation.

United Kingdom		
R Squared: 0.4142	Durban Watson: 0.5823	
	Constant	**Gini**
Coefficient	97.985	-0.5439
t-stat	18.89	-3.47
Standard error	5.1859	0.1569

Table 8 - OLS Regressions results for the UK

Portugal		
R Squared: 0.6593	Durban Watson: 0.4060	
	Constant	**Gini**
Coefficient	104.6493	-0.7037
t-stat	22.71	-5.39
Standard error	4.6090	0.1306

Table 9 - OLS Regression results for Portugal

Latvia		
R Squared: 0.4405	Durban Watson: 1.4257	
	Constant	**Gini**
Coefficient	105.5382	-0.8969
t-stat	10.06	-3.07
Standard error	10.488	0.2918

Table 10 - OLS Regression results for Latvia

The Netherlands		
R Squared: 0.2999	Durban Watson: 0.3717	
	Constant	**Gini**
Coefficient	99.0535	-0.6939
t-stat	13.08	-2.45
Standard error	7.5732	0.2833

Table 11 - OLS Regression results for the Netherlands

Estonia		
R Squared: 0.2964	Durban Watson: 1.7	
	Constant	**Gini**
Coefficient	100.1043	-0.7495
t-stat	10.38	-2.60
Standard error	9.6422	0.2887

Table 12 - OLS Regression results for Estonia

Belgium		
R Squared: 0.6929	Durban Watson: 1.3623	
	Constant	**Gini**
Coefficient	104.0318	-0.8912
t-stat	26.07	-6.01
Standard error	3.9909	0.1483

Table 13 - OLS Regression results for Belgium

The results obtained thereby support the Wilkinson Hypothesis as the contemporaneous Gini coefficient is statistically significant and takes the negative sign that would imply a negative relationship between income inequality and life expectancy. Furthermore, the coefficient of this Gini coefficient is relatively large, thereby indicating income inequality does have a considerably detrimental impact on life expectancy in these six EU countries. To this end, the coefficient representing the weakest detrimental impact of income inequality on life expectancy is that of -0.5439 for the United Kingdom. This would mean that a unit increase in income inequality as measured by the Gini coefficient would be associated with a decline in life expectancy in the United Kingdom of around 0.54 years, ceteris paribus.

Whilst the coefficients representing the strongest impacts were those of -0.8969 and -0.8912 for Latvia and Belgium respectively. Such coefficients would mean that a unit increase in income inequality as measured by the Gini coefficient would be associated with a decline in life expectancy in both Latvia and Belgium of around 0.89 years, ceteris paribus– almost a full year of human life.

On average, the magnitude of the impact was that of -0.7465. Essentially, this would mean that a unit increase in income inequality as measured by the Gini coefficient would be associated with a decline in life expectancy of around three quarters of a year, ceteris paribus.

Whilst not a result in itself, an interesting observation that arose from this second line of investigation was that for many EU countries, income inequality has actually been growing since the year 2000, even before the economic disruption of the Financial Crisis and the Great Recession.

Going beyond merely offering academic value by supporting the Wilkinson Hypothesis for some EU countries, the results of this second line of investigation thereby highlight the damaging effects on life expectancy that arise as a result of the existence of a material relationship between income inequality and life expectancy in some EU. This finding therefore gives weight to the argument that there must be a policy response to the existence of this relationship and its effects on society and the economy.

Due to the rather low Durban Watson statistics, it may be the case that the time series for Portugal, the Netherlands and the United Kingdom may suffer from some degree of autocorrelation. Therefore, the results described above are to be treated with caution. To remedy this, the models were re-estimated in first differences. The results of these additional estimations are shown hereunder.

Portugal		
R Squared: 0.0897		
	Constant	**dGini**
Coefficient	79.9787	-0.5361
t-stat	217.93	-1.13
Standard error	0.3670	0.4735

Table 14 - OLS regression results for Portugal after first difference transformation

The Netherlands		
R Squared: 0.2100		
	Constant	**dGini**
Coefficient	80.8235	0.5718
t-stat	289.85	1.79
Standard error	0.2759	0.3202

Table 15 - OLS regression results for the Netherlands after first difference transformation

United Kingdom		
R Squared: 0.0184		
	Constant	**dGini**
Coefficient	80.1433	-0.1201
t-stat	292.68	-0.55
Standard error	0.2738	0.2195

Table 16 - OLS regression results for the UK after first difference transformation

As is apparent from the above results, after the first difference transformation, the relationship that was found in the previous OLS regressions between Gini and LE breaks down for Portugal, the Netherlands and the United Kingdom. However, due to the relatively more promising dynamics behind the evolution of the Gini coefficient in these countries over the time period, it was decided that the second line of investigation should continue to feature these three countries as part of the group with Belgium, Estonia and Latvia.

Final Panel Data estimation using longer data set for only LE and Gini

Motivated by the results obtained from the OLS Regression analysis, another panel data was assembled containing only data on the aforementioned six countries and using the longer data set containing only LE and Gini. The results of both the Pooled OLS and Fixed Effects estimation are represented in the table below.

Panel Estimation using longer data set attained by dropping HEPC and Educ

Pooled OLS

Dependent Variable: LE		
	Constant	**GINIt**
levels		
R-Squared: 0.3320		
Coefficient	93.1566	-0.4678
t-stat	43.85	-7.05
Sd error	2.1243	0.0664

Fixed Effects Estimator

Dependent Variable: LE		
	Constant	**GINIt**
levels		
R-Squared (within): 0.4047		
Coefficient	101.4135	-0.7276
t-stat	35.22	-8.04
Sd error	2.8798	0.0905

Table 17 - Panel Data Estimation for only LE and Gini using the longer data set used in the previous OLS estimations

Whilst both the Pooled OLS and Fixed Effects estimations yielded very similar results, focusing on the more reliable Fixed Effects results would indicate that in this model estimation the Gini coefficient is statistically significant and takes the expected negative sign, such that a unit increase in income inequality as measured by the Gini coefficient can be associated with a decrease in life expectancy in these six countries equivalent to around 0.73 years, ceteris paribus.

Therefore, it may be suggested that over an adequately long period of study, the Panel Data estimation results support the Wilkinson Hypothesis in the EU for the country group of Belgium, Estonia, Latvia, Portugal, the Netherlands and the United Kingdom.

CHAPTER 5

POLICY IMPLICATIONS AND AVENUES FOR FUTURE RESEARCH

Policy Implications

The importance of using policy to close the income inequality gap

As evidenced by the results of the second line of investigation of this dissertation as well as the volume of literature referenced in the Literature Review section of this dissertation, the size of the income inequality gap within a particular population can have a significant detrimental effect on population health outcomes in the form of decreases in life expectancy. As explained in the Empirical Analysis and Results chapter of this dissertation, the second line of investigation yielded findings that support the Wilkinson Hypothesis in Belgium, Estonia, Latvia, Portugal, the Netherlands and the United Kingdom. These findings, together with the weight of literature advocate for the existence of a strong, persistent negative relationship between income inequality and population health outcomes for at least a number of EU countries. The harmful effects that income inequality has on population health outcomes can therefore not be disregarded.

Whilst the last few decades have seen governments and policy makers direct increasingly more of their attention towards the issue of the income inequality gap and the importance of reducing the size of this gap (particularly as part of their poverty fighting agendas), there still remains a lot that can be done in this regard.

The harmful effects that income inequality can have on population health and the direct and indirect economic costs that arise as a result of this harm to population health could be significant enough in nature for governments and policy makers to allocate more resources and funding towards schemes, policies and the construction of institutional mechanisms that can facilitate the closing of the income inequality gap over both the medium and long term. Whilst various actions have been taken and many plans implemented in this regard over the last few years, these have been undertaken with varying degrees of success and effectiveness. In light of this, the results of this dissertation, as well as multiple papers in the literature that have been reviewed and analysed in the process of writing this study, advocate for governments and policy makers to attain a non-superficial understanding of the transmission channels through which the income inequality gap impacts population health. This should be done to the extent that governments and government entities should invest the time, money and human resources into developing small task forces that are capable of investigating the income inequality – population health dynamic specific to the country in question (with an emphasis placed on the practical aspects of policy design in mind). Such task forces could provide reports and take a front seat in the design and implementation of policies and schemes targeting poverty. Such an institutional set up could be extremely effective while also being relatively resource efficient. Furthermore, such task forces could also be set up at EU level, with a specific EU fund set up in this regard, to support and maintain schemes devised through the working groups. One of the main benefits that may arise from such a set up would be the creation of a creative thinking space that could give rise to innovations in policy design.

At this point it should also be worth noting that many influential authors on the topic such as Kate Pickett and Richard Wilkinson have emphasised that government policies that are focused on redistributing wealth can be effective and very viable to implement as a means of combatting poverty whilst offsetting the harmful effects that income inequality has on population health. However, such authors advocate that governments and policy makers should not only steer policies and interventions toward redistribution mechanisms only, but that such actions should be steered towards reducing the pre-existing income inequality gap. From this perspective, it is worthwhile to focus on the fact that most mechanisms that redistribute wealth across society are usually redistributive tax based policies. Therefore, the emphasis should be put on reducing the initial income gap before taxation (Picket and Wilkinson, 2015).

It would be appropriate to conclude this section on policy implications by emphasising the point made in Lynch et al (2004) and reiterated in Rowlingson (2011) that in order to improve population health and population welfare outcomes, governments must target both the reduction of poverty as well as the reduction of the income inequality gap. Whilst these pose significant challenges to governments and policy makers alike, these two target avenues are mechanically tied together such that both avenues can be targeted simultaneously as using policy that raise the incomes of disadvantaged individuals could be effective in reducing the income inequality gap whilst also improving the standard of living and health outcomes of the relatively poorer segments of the population. If done correctly, and in a manner that impacts a large enough segment of the population over several years, then this could create a very desirable positive feedback loop as over the medium to long term wealth inequalities in society decrease with population health outcomes improving – which should bring about better living standards and a smaller income inequality gap for future periods and possible even for future generations if inter-generational transmission channels function correctly.

Furthermore, the results of this dissertation have shown that the magnitude of the detrimental effect income inequality has on life expectancy is relatively large for the six countries mentioned previously. Hence, if implemented policies succeed in reducing income inequality in those six countries, then theoretically speaking, population health outcomes may improve significantly. This would have two main implications. Firstly, the improvement in population health outcomes (especially if these are sustained over the long term) should also result in increases in productivity and other socio-economic outcomes. Secondly, this should also slightly reduce the strain on the healthcare systems as less treatment, interventions and medications would be required to treat morbidities that arise in whole or part due to income inequality. That being said, it is likely that lower income households and households classified as being in or at risk of poverty would stand to experiences the most material gains in this regard. Another aspect to this second point is that given any particular level of HEPC, such a sustained decrease in income inequality and the resulting improvements in population health outcomes may allow for healthcare sector resources to be redeployed and reutilized to cater for individuals that would have otherwise been crowded out. Additionally, for countries with large public healthcare sectors, such improvements would also relieve some degree of strain on public finances and resources.

The findings validate the direction of national and supra-national resources and efforts toward education attainment and health care access

The most emphatic findings of this study relate to the significant roles that education attainment and health care expenditure per capita (HEPC) have in influencing population health outcomes (as measured by life expectancy) within the EU. As explained at length in the previous section of this dissertation, there seems to be evidence that sufficiently indicates that education attainment (as measured by the number of years in formal education) as well as health care expenditure per capita (HEPC) have a consistent, strong, positive impact on life expectancy given the level of income inequality, both contemporaneous and lagged by one year, within the population.

Education attainment can be a key target variable for improving population health outcomes

A key policy implication of the strength of the influence that education attainment has in determining population health (manifested by life expectancy) is that education attainment can serve to be a key target variable for government and policy makers in their efforts at improving population health. Put more straightforwardly, if an EU member state government or policy making entity wished to design and implement policies to improve population health outcomes, then orienting such policies around inducing significant and sustained improvements in education attainment (especially with regard to increasing the number of individuals attaining post-secondary and university level schooling) could potentially be a highly effective and efficient means of achieving the desired outcomes in both the medium term and the long term.

As already explained, the findings of this dissertation have shown that the effectiveness of this target variable in improving population health outcomes may vary depending on the specific geographic, ethnic and cultural characteristics of the particular EU member state country in question. Hence, at a country level, prior investigation may be required in order to determine how much of an successful impact should be expected from such policies, given the financing and resources that such policy require. Whilst positive outcomes of moderate magnitude should indeed result even in the countries with a relatively high GDP, such cost-benefit analysis may be required to establish exactly whether such policies represent an optimal use of public resources as a means to improve population health outcomes. Furthermore, the type of long term commitment and political willingness required to implement such policies would also require some assurance of a minimal degree of forecasted cost effected success.

Nonetheless, policy maker knowledge and sensitivity regarding the potential efficacy of policies being somewhat dependent on socio-cultural characteristics could be crucial for ensuring that any policy will be designed and implemented in a manner that ensures that any outcomes will be as Pareto Efficient as possible.

Education attainment can be a key target variable for improving broader population outcomes

Another potential policy implication of the strong influence that education attainment has in impacting life expectancy is that the transmission channels through which education attainment influences life expectancy may represent an opportunity for education attainment to also serve as a target variable through which policy makers can impact broader population outcomes such as general population welfare as well as poverty levels. By inducing higher levels of education attainment, a significant proportion of the lower income portion of the population are likely to experience upward economic mobility into higher levels of income – thereby leading to sustained improvements in a multitude of socio-economic outcomes.

The use of using Healthcare Expenditure per capita as a target variable to improve population health outcomes

As explained in depth in the Empirical Analysis and Results section of this dissertation, the Healthcare Expenditure per capita (HEPC) variable plays a strong role in determining life expectancy within the EU. Whilst this relationship between HEPC and life expectancy may break down for Southern and low GDP countries, the impact of HEPC on life expectancy is large and stable and not overly sensitive to the particular geographic, ethnic, cultural or national wealth characteristics of the particular EU country in question. In light of this, HEPC would make a very effective variable to target for policy makers seeking to induce improvements in population health outcomes. An optimal approach to instigating improvements in population health outcomes through increases in HEPC would most likely be to use state resources to bring about significant and sustainable increases in HEPC in a manner that reflects an equity based distribution of the increases in HEPC across the population. In particular, this would likely necessitate that a significant proportion of the increase in HEPC would arise through lower income households enjoying a proportionately large share of the resources spent on increasing HEPC. By closing the inequality gap with respect to healthcare access between lower and higher income households, more members of the population can gain from the benefits of higher levels of HEPC, thereby drastically increasing population health outcomes.

As explained in the previous chapter, the transmission channels through which HEPC affects life expectancy do not seem to be overly sensitive to the geographic, ethnic and cultural characteristics of particular EU member states and it is therefore likely that direction (or redirection) of state finances and resources towards increasing HEPC would represent am efficient and validated use of state resources, regardless of the EU member state in question.

Once again, policy maker knowledge and sensitivity to the potential efficacy of policies being somewhat dependent on socio-cultural characteristics could be crucial for ensuring that any policy will be designed and implemented in a manner that ensures that any outcomes will be as Pareto Efficient as possible.

Avenues for Further Research on the Topic

Given the research conducted in this dissertation as well as the conclusions drawn, the sheer vastness of the topic means that there are a multitude of additional avenues of inquiry that are worth exploring. Various salient avenues for future research are those explained hereunder.

Investigating the similarities and differences between the transmission channels for the EU and USA through which income inequality impacts population health outcomes

Given the results obtained in this dissertation, in particular those that support the Wilkinson Hypothesis in six EU member states, it could be particularly interesting for future research to investigate the qualitative nature of these transmission channels within the EU for each country individually. This would facilitate further research into understanding better why the income inequality – life expectancy relationship dynamic plays out so differently between those six EU countries and the other 22 member states.

Furthermore, these transmission channels can then be compared and contrasted with those of the USA. Such investigation could be particularly fruitful as studies on the USA tend to produce results that consistently support the Wilkinson Hypothesis across the entirety of the country – whereas this may not be the case for the EU.

Studying the effects of permanent socio-economic changes

It would be extremely interesting for future research to investigate how the relationship between income inequality and life expectancy within specific EU countries or groups of countries has changed over a long period of time, particularly with regard to various permanent socio-economic developments within the economy or society. Studies focusing on such natural experiments or quasi natural experiments would allow researchers to develop an understanding of how the underlying dynamics behind the relationship between income inequality and population health outcomes could be affected by significant policy changes such as the increase or introduction of minimum wage legislation or significant socio-economic changes such as the establishment of the EU and the Common Market.

Investigating the Wilkinson Hypothesis across various socio economic strata for multiple countries within the EU

Rather than investigating the nature of the relationship between income inequality and life expectancy for the entire EU, it could be rather fruitful for future research to investigate this relationship across the EU by focusing only on a specific socio-economic stratum of the population. This approach could be self-contained as a complete piece of research in its own right or it could be repeated for each socio-economic stratum to develop an understanding of how the dynamics of the income inequality – population health outcome relationship play out by disaggregating the relationship. It is highly likely that in order for such an analysis to be carried out, an alternative measure of income inequality might required rather than the traditional Gini coefficient. Such research would require a measure of income inequality that captures the distribution of the income inequality within each specific socio economic stratum and would thereby require an appropriately adjusted Gini coefficient or else, a completely different variable entirely.

Investigating more precisely how ethnicity and culture impact the income inequality - life expectancy relationship

Whilst certainly not being the first to do so, this dissertation has investigated how significant variations in the degree of ethnic and cultural fractionalisation within countries could have a potential impact on the nature of the relationship between income inequality and population health outcomes within groups of countries within the EU. In light of this, future research could investigate this in more depth, possibly by building a more complex and complete model that adequately controls for ethnic and cultural factors that relate directly to how the underlying population is made up. Whilst such research may require an additional degree of care and attention to the potential sensitivities of the topic as well as of the conclusions reached, research such as this could be extremely valuable in yielding results and conclusions that could aid in the design of more effective public and social policies that could be targeted at poverty reduction or quality of life improvements for specific minorities that may be disproportionately disadvantaged by the harmful effects of income inequality within the EU. Furthermore, such research could also be extended to investigate how ethnic, cultural and geographic variations impact the relationships between both HEPC and education attainment and population health outcomes.

Investigating the sensitivity of the outcome of studies on the Wilkinson Hypothesis in the EU to variations in the measure of population health outcomes

Whilst this study focuses on only one measure of population health outcomes, the literature review section of this study and the papers explored therein have brought to light how the ultimate results and conclusions of research on the topic, especially with regard to evidencing the existence of the Wilkinson Hypothesis, can vary significantly with the choice of measure of population health outcomes. It could therefore be very worthwhile for future research to re-build and re-estimate the model used in this study (and others) using different measures for population health outcomes. This could be undertaken by replacing the life expectancy measure with other measures that have been used in the literature such as child mortality rates, health status as measured by self-reported health as well as other options such as various specific morbidity rates (such as the case rate for particular types of cancers). Whilst such research and the conclusions thereby drawn would be extremely valuable in their own right, they could also have a lot of value with regard to challenging or reaffirming the results obtained in this dissertation as well as reaffirming and challenging the results obtained in other similar studies. Furthermore, such an approach to future research could have the added value of using a measure of population health outcomes that is less general in nature and scope than life expectancy and could thereby also bring to light certain aspects of the income inequality – population health relationship that can be tied to specific health outcomes without being drowned out by other a pool of other outcomes that are captured in tandem by generic measures such as life expectancy.

Investigating whether there exists a threshold value for in the transmission of the effects of income inequality

As outlined in the literature review section of this dissertation, studies on the topic that focus on the United Stated have yielded results that suggest that given the socio-economic transmission channels through which income inequality can impact population health outcomes, there is the possibility of the existence of a threshold value for income inequality above which the detrimental effects of income inequality become relatively more aggressive relative to situations when the measure of income inequality is below this threshold. Therefore, in order to develop a more complete understanding of not only the Wilkinson Hypothesis, but also of the relationship between income inequality and population health outcomes within the EU, it would be worthwhile for future research to investigate whether such a phenomenon exists in the EU, even if this would require investigating particular countries only rather than groups of countries or the EU a whole. Besides being innately valuable and important, such research would also be useful in helping economists understand how better to focus the research in the field. This could come about as if certain countries that are similar in key socio-economic characteristics as the USA (such as the UK) exhibit the afore mentioned threshold characteristics then future research could be directed toward pinning down the exact transmission channels that allow this effect to materialize. On the other hand, if this threshold effect is found in countries that are socio-economically starkly different to the USA, then this could motivate research and economic thought towards developing new theoretical frameworks that could provide a more complex explanation for the transmission of the effects of income inequality across population health outcomes and other aspects of population related economic outcomes. Furthermore, it could also be possible that no such threshold effect exists in the EU, which would of course be a very interesting finding, and would itself motivate more avenues of investigation in that regard.

Investigating how the nature, size and complexity of public institutions impacts the relationship between HEPC and population health outcomes as well as the relationship between education attainment and population health outcomes within the EU

Whilst already touched upon to some degree in the literature, it could be fruitful if future research efforts are directed towards investigating the role played by public institutions in affecting how HEPC and education attainment influence population health outcomes. An intuitive first step to undertaking such an approach would be to build a model similar to the one used in this dissertation with this model being augmented in a manner such that it could constitute a variable that measures the relative size of the health sector of the economy that is public and provides health care services and medications as merit goods and services to qualifying members of the population. Naturally, such a variation in the modelling process would necessitate that such a variable would substitute the Healthcare Expenditure per capita variable employed in the model used in this study.

It would also be possible to make this avenue of investigation relatively more complex and detailed by taking it a step further to also include public institutions in general in order to investigate how the strength and health of public institutions can have on the relationship between income inequality and population health outcomes. This approach could be undertaken by measuring the health of public institutions by focusing on elements such as transparency, size, public trust, corruption indexes and so on.

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APPENDIX

List of EU member states categorized as Northern – Model 2

Austria
Belgium
Czech Republic
Denmark
Estonia
Finland
France
Germany
Ireland
Latvia
Lithuania
Luxembourg
Netherlands
Poland
Slovakia
Sweden
United Kingdom

List of EU member states categorized as Southern – Model 3

Bulgaria
Croatia
Cyprus
Greece
Hungary
Italy
Malta
Portugal
Romania
Slovenia
Spain

List of EU member states categorized as having High GDP– Model 4

Austria
Belgium
Denmark
Finland
France
Germany
Ireland
Italy
Luxembourg
Malta
Netherlands
Spain
Sweden
United Kingdom

List of EU member states categorized as having Low GDP– Model 5

Bulgaria
Croatia
Cyprus
Czech
Republic
Estonia
Greece
Hungary
Latvia
Lithuania
Poland
Portugal
Romania
Slovakia
Slovenia

List of EU member states categorized as exhibiting a high degree of ethnic fractionalization – Model 6

Belgium
Bulgaria
Croatia
Czech Republic
Estonia
Germany
Greece
Latvia
Lithuania
Luxembourg
Romania
Slovakia
Slovenia
Spain

List of EU member states categorized as exhibiting a low degree of ethnic fractionalization – Model 7

Austria
Cyprus
Denmark
Finland
France
Hungary
Ireland
Italy
Malta
Netherlands
Poland
Portugal
Sweden
United Kingdom

Results of Levin-Lin-Chu test

Variable	Bias Adjusted t-statistic	Statistically Significant	Null Hypothesis	Stationary
LE	-9.4649	Yes	Rejected	Yes
GINIt	-5.1698	Yes	Rejected	Yes
Ginit1	-5.9932	Yes	Rejected	Yes
HEPC	-39.2225	Yes	Rejected	Yes
Educ	-14.9042	Yes	Rejected	Yes