A macroeconomic investigation of how health impacts economic growth: analysing the European Economic Area

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Abstract

This dissertation examines the macroeconomic relationship between health and economic growth for the European Economic Area (EEA) over 18 years covering the period of 2002 to 2019. It was hypothesised that health effects economic growth for EEA countries over the 18 years studied, shown through positive statistical significance of life expectancy from birth on Gross Domestic Product (GDP) per capita. Other independent variables used as control variables in the regression include the age dependency ratio, net migration, trade openness, inflation, government expenditure, investment, population density, political stability and capital spend per worker. A two-stage least squares (2SLS) model with time and entity fixed effects was employed to address potential endogenous in the relationship between GDP per capita and life expectancy. The main result of this study is that life expectancy has a statistically significant positive effect on GDP per capita at a 5% significance level. A 1-year increase in life expectancy, increases GDP per capita by 9.6% for the EEA countries studied between 2002-2019. The results from this research illustrate the importance of good public health on economic growth using macroeconomics and econometrics. The findings may influence EEA policy makers as they reflect the importance of a healthy population. This may lead to potential policy effects including increased health expenditure, the creation or adoption of policies to improve public health and further analysis on human capital impacts of mortality and morbidity.

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Introduction

Good human health is of value to individuals, society and the economy. This is because health directly effects ability, productivity and well-being of individuals, therefore impacting labour market participation and worker productivity. In addition, healthy individuals are more likely to invest in education, be part of the labour force, generate a salary and contribute to the economy. Good health also reduces healthcare expenditure and prevents significant economic disruption from disease and infection. In economic literature health is referred to as an influential factor of human capital for which plays a significant role in the Cobb-Douglas production function and as part of the Solow Growth model.

The World Health Organisation define health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (World Health Organization, 2023). Good human health is of value to individuals, society and the economy. This is because health directly effects ability, productivity, and well-being of individuals, therefore impacting labour market participation and worker productivity (Tompa 2002). Healthy individuals are more likely to be part of the labour force, generate a salary and contribute to the economy. Good health also reduces healthcare expenditure and prevents significant economic disruption from disease and infection.

“Economic growth describes an increase in the quantity and quality of goods and services that a society produces and consumes” (Roser.M, 2013). Economic growth is a primary objective for most countries internationally as it improves the standard of living, reduces unemployment through job creation, improves equality and increases innovation through investment. There are many factors that contribute to economic growth, with health not always being the most obvious. The Solow Growth model refers to an exogenous neoclassical economic model that considers long run economic growth to be a function of human capital, physical capital and factor productivity, mainly driven by technology (Feldstein, M, 1992). This study aims at assessing the impact of health within this function as an influential factor on human capital.

Historic literature mainly indicates a positive casual effect of life expectancy on GDP per capita, however there are mixed results for developed economies. Past empirical analysis covers a range of countries and time periods to analyse the relationship between health metrics and economic growth but there is a gap in the literature where EEA countries have not been investigated. Different papers also cover topics such as long run vs short run differences, country development level differences, different use of health metrics and microeconomic vs macroeconomic comparison which generate a range of results. There are limited up to date studies that assess the health-growth relationship in the 21st century, especially for developed economies. This study will address these gaps in the literature and aim to assess EEA countries within the 21st century.

This dissertation uses regression analysis and econometric techniques to assess the macroeconomic relationship between health and economic growth. The study hypothesises that health (represented by life expectancy from birth) has a statistically significant positive effect on economic growth (represented by Gross Domestic Product (GDP) per capita) for countries within the European Economic Area (EEA) from 2002 to 2019.

This dissertation is structured in the following order: review of existing literature focusing on economic theory, the relationship of health and economic growth and literature that uses regression and econometric analysis similar to that studied and used in the development of this paper; analysis and discussion of the data and variables used in the regression model; methodology for the model and robustness checks; results and discussion and finally project outcomes including conclusions and recommendations.

Literature Review

Economic theory:

The relationship between human health and economic growth is complex and multifaceted. To understand and isolate the impact of health on economic growth, literature highlights the economic theory behind health being a key component of human capital which is a main driver for economic growth (Sharma.R, 2018 ,Bloom, 2019, Ridhwan et al., 2022). This theory is mainly discussed through the use of production functions which mathematically breakdown how the inputs of human capital, physical capital and productivity are transformed into total output.

Sharma (2018) discusses the impact of a healthier workforce benefiting the economy through increased longevity and lower rates of absenteeism and presentism, which refer to sickness absence and illness whilst working. Further to this, Sharma states that a healthy workforce improves innovation which can significantly impact the use and development of physical capital. However, increased longevity is said to negatively GDP per capita due to the spreading of existing resources being stretched over a larger and potentially older population.

Bloom (2019) describes health as an "essential component of human capital". Bloom (2019) goes on to discuss the importance of physical and mental capability when assessing how health can drive economic growth. It is also stated that higher life expectancy increases incentives to invest in education which progresses innovation. The paper explains the impact of health using a production function model that breaks down human capital into influential factors on wages such as health and education.

Ridhwan (2022) explains how health affects economic growth directly by increasing labour productivity and decreasing the costs of illnesses. It is also mentioned that good health conditions enable and incentivise people to acquire further education and skills. Following on from the work of Weil (2014), Ridhwan (2022) develops the Cobb-Douglas production function using a measure of "returns of health" and simplifies the production function:

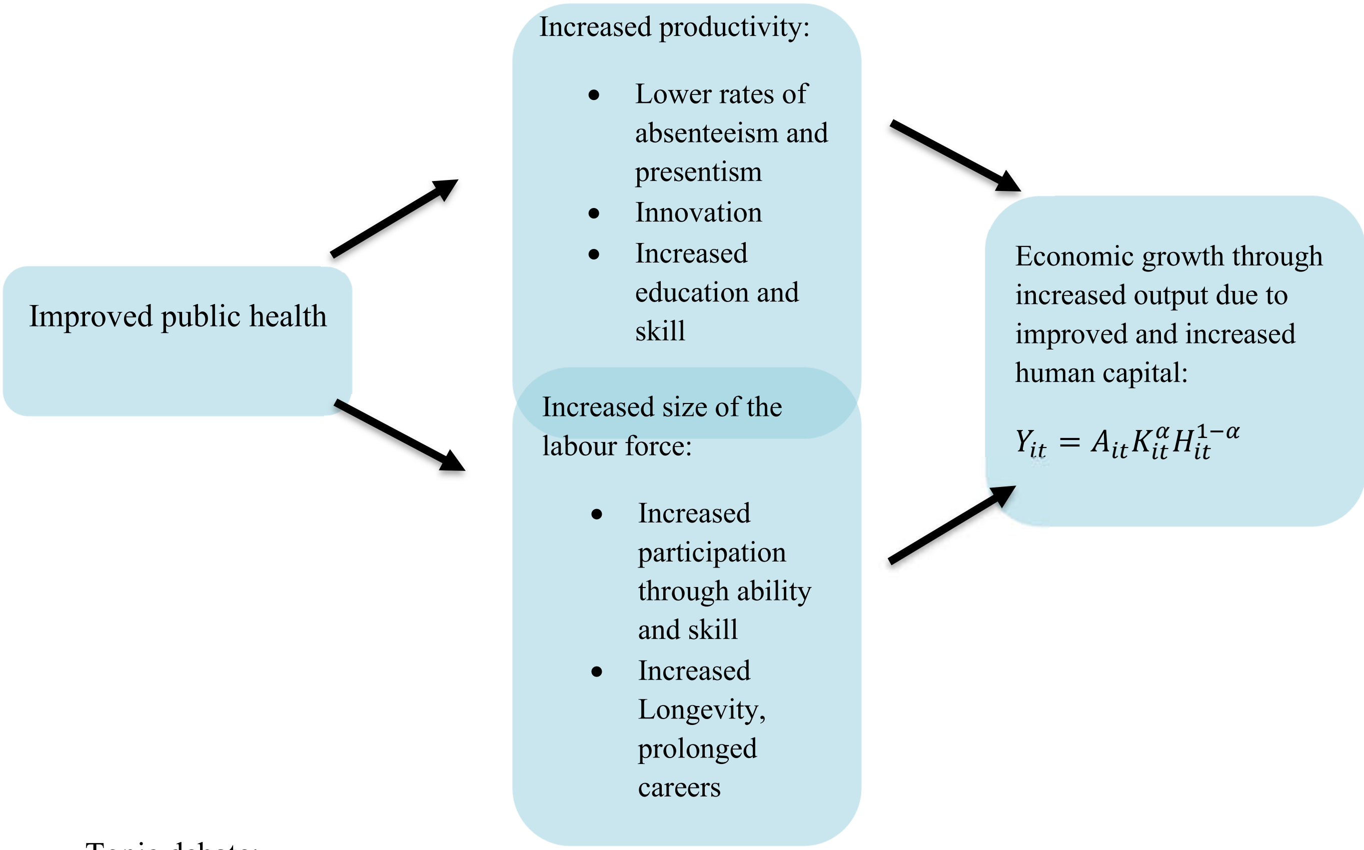
$$Y_{it} = A_{it} K_{it}^{\alpha} H_{it}^{1-\alpha}$$

"Where Y is output, K is physical capital, H is the aggregate of human capital stock and A is a productivity term. i indexes the countries and t indexes the specific times" (Ridhwan et al., 2022).

Tompa (2002) reviews how health measures impact the standard of living (measured by GDP per capita). They associate improved productivity through health gains including increased longevity increasing labour supply through longer careers, reduced absenteeism and enhanced motivation. Tompa (2002) goes on to discuss how human capital, effected by productivity impacts GDP per capita in a positive way.

All papers mention the link between health and economic growth through the impact of health on human capital. The flow diagram below summarises the impacts mention by the studies above:

Figure 1: Flow diagram summarising how health has a direct positive impact on total output.



Topic debate:

Historic literature on the relationship between health and economic growth mainly indicates a positive casual effect of life expectancy on GDP per capita, however there are mixed results for developed economies. Empirical analysis covers a range of countries and time periods to analyse the relationship between health metrics and economic growth. Different papers also cover topics such as long run vs short run differences, country development level differences, different use of health metrics and microeconomic vs macroeconomic comparison:

Swift (2011) examines the relationship between life expectancy and both GDP and GDP per capita for 13 OECD countries over the past two decades. Their results show a positive effect of life expectancy on both GDP and GDP per capita in the long run, with different strengths of the relationship between OECD countries. Swift (2011) also analysed the short run relationship and found no significant short run effects on GDP or GDP per capita for most OECD counties.

Ridhwan (2022) creates a meta-analysis which assesses the effect of health on economic growth based on 64 studies. They show that health has a genuine positive effect on economic growth through different studies. It is also proven that the impact is much greater for developing countries compared to developed countries.

Bhargava (2001) investigates the effects of adult survival rates on GDP growth rates in 92 and 72 countries using different dependent variables. This study analyses GDP series based on purchasing power adjustments and on exchange rates. They found significant positive effects of adult survival rate on economic growth rates for developing countries but a negative effect for developed countries.

Sharma (2018) also assesses the health-growth relationship using life expectancy as approximation for population health. Sharma (2018) reported a positive and significant effect on both real income per capita as well as growth rates. They analysed 17 advanced economies between 1870 and 2013.

Bloom (2019) assesses the micro-macro puzzle which arises due to mixed literature findings. Bloom uses a macroeconomic approach and compares the results to a microeconomics study completed by Weil's (2007). Bloom concludes that both approaches support the same result of health metrics having an impact on economic growth.

Acemoglu and Johnson (2007) analyses a full sample of 75 countries across 1940-1980 (or 2000 for an extended sample) and found that an increase in life expectancy caused a significant increase in population size. They also found a positive effect of life expectancy on total GDP. However, when analysing GDP per capita, they found that an increases in life expectancy reduced GDP per capita because of the overpowering population size.

Barro (1996) used data covering 100 countries from 1960 to 1990 and concludes that there is a positive impact of life expectancy alongside other factors that impact growth such as education, lower fertility rates, lower government consumption, better maintenance of the rule of law, lower inflation, and improvements in the terms of trade.

Neofytidou and Fountas (2020) looks at the impact of health on GDP per capita using panel data of 19 developed economies over a time series of 1950-2013. This paper investigates the short-run and long-run relationship and report that life expectancy has a positive and statistically significant effect on both short-run and long-run on GDP and GDP per capita.

Empirical analysis:

Health is a complex variable to model and is shown in the literature to be measured in various ways, the meta-regression analysis performed by Ridhwan (2022) examines 64 studies on the topic area of health and economic growth and shows life expectancy as the most consistently used macroeconomic indicator, followed by the measure of adult survival rates.

To investigate the causal effect of health (measured by life expectancy) on economic growth (measured by GDP per capita), this dissertation assesses a balanced panel of data for 30 countries over 18 years. Historic studies cover a range of data and use different methods in aim of getting robust results. Using panel data over cross-sectional data allows for a better identification of a causal relationship, less biased results and can control for heterogeneity across countries as well as time invariant factors. There have been a range of panel data models for which are similar to those modelled in this study but investigate different health metrics, time periods and groups of countries:

Bhargava (2001) investigated the effect of adult survival rates on GDP growth rates from 1965 to 1990. This study assessed groups of both 92 and 72 countries using a GDP series based on purchasing power adjustments and on exchange rates. The study uses a random effects models containing endogenous regressors. They identified a significantly positive effect of the adult survival rate on the economic growth rate for low-income countries but a negative effect of the adult survival rate on the economic growth rate for high-income countries.

Biyase (2019) analysed the relationship between life expectancy and economic growth (measured by GDP per capita) in a sample of 10 "Southern African Development Community members" for the period 1985 to 2017. The paper uses a fixed effects model to account for unobserved country level heterogeneity and then applies a fixed effects two-stage least squares estimator to account for endogeneity bias due to potential bidirectional causality between life expectancy and GDP per capita. The paper concludes that life expectancy has a statistically significant positive effect on economic growth.

Hansen and Lønstrup (2015) examines the effect of growth in life expectancy on the growth in GDP per capita. The paper has a pre-treatment period of 1900–1940 and the post-treatment period of 1940–1980 to analyse the effect of the mortality shock caused by the wave of medical innovations around 1940s to the mid-1950s. The base sample consists of 35 countries and applied a two-stage least squares model with fixed effects. The main finding of this study was that here was a negative effect of life expectancy growth rates on GDP growth rates.

Data and variables

The research for this project draws from multiple secondary data sources to be able to create a balanced panel of data. The data consists of 30 EEA countries including the UK as it was part of the EEA during the time periods of this study. Unfortunately, there was not complete data for Liechtenstein meaning this country has not been included within the results of this study. The data period studied is from 2002 to 2019 which was selected in aim of producing a modern assessment of the health-growth relationship whilst also having complete data for all variables in the model.

Table 1 identifies the variables used in the regression, explains how they are calculated and provides summary statistics of the data.

Log GDP per capita is the dependent variable. The model assesses the impact of the independent variables on GDP per capita using statistical techniques. With the aim of looking at the impact of health on economic growth, GDP per capita was an obvious dependent variable to analyse as it is one of the most used metrics when measuring economic growth (Ridhwan,2022). GDP per capita accounts for population size and is comparable across countries.

Life expectancy is the macroeconomic health indicator used in this study as the main independent variable. Life expectancy is repeatedly used in regression analysis in a range of studies. It was reported as the most popular macroeconomic health indicator in the meta-analysis by Ridhwan (2022). Life expectancy is also very highly correlated with other health metrics including healthy life expectancy at birth, adult mortality rate and child mortality, which all have over a 0.9 correlation with life expectancy (Sharma,2018).

Other independent variables used as control variables in the regression include the age dependency ratio, net migration, trade openness, inflation, government expenditure, investment, population density, political stability and capital spend per worker.

The group of independent variables were inspired by a range of literature relating to economic growth. It is important to include control variables when performing regression analysis to reduce omitted variable bias and improve the robustness of the results.

Table 1: Variables (covering 30 countries, over 18 years)

Variable	Source	Description	Summary statistics
GDP per capita	World Bank	Gross Domestic Product (GDP) per capita measured in current U.S. dollars. Calculated by GDP divided by midyear population.	Maximum: 123679 Minimum: 2093 Mean: 33399 Standard Deviation: 23028 Observations: 540
Life expectancy	World Bank	Life expectancy at birth, total (years) measured by the number of years from birth an individual would survive if mortality patterns were to stay the same over the period of life.	Maximum: 84 Minimum: 71 Mean: 79 Standard Deviation: 3 Observations: 540
Age dependency	World Bank	Age dependency ratio (% of working-age population) is the ratio of dependents per 100 working-age population.	Maximum: 62 Minimum: 39 Mean: 50 Standard Deviation: 5 Observations: 540
Net migration	World Bank	Net migration measured by total immigrants minus total emigrants.	Maximum: 774489 Minimum: -254292 Mean: 42792 Standard Deviation: 115129 Observations: 540
Trade openness	Our World in Data	Trade openness (share of exports and imports in GDP). Calculated by the sum of exports and imports divided by GDP.	Maximum: 408 Minimum: 45 Mean: 116 Standard Deviation: 64 Observations: 540
Inflation	World Bank	Inflation, GDP deflator (annual %) measures the annual growth rate of GDP.	Maximum: 23 Minimum: -10 Mean: 3 Standard Deviation: 3 Observations: 540
Government spend	World Bank	General government final consumption expenditure (% of GDP) Measuring total spend on goods and services.	Maximum: 28 Minimum: 12 Mean: 20 Standard Deviation: 3 Observations: 540
Investment	World Bank	Investment measured by gross capital formation (% of GDP). Includes additions to the fixed assets and net changes in inventories.	Maximum: 55 Minimum: 12 Mean: 23 Standard Deviation: 5 Observations: 540
Population density	World Bank	Population density measured by midyear population per square kilometres of land.	Maximum: 1575 Minimum: 3 Mean: 164 Standard Deviation: 242 Observations: 540
Political Stability	World Bank	Political Stability and Absence of Violence/Terrorism: measures by cross country percentile Rank	Maximum: 100 Minimum: 30 Mean: 75 Standard Deviation: 16 Observations: 540

Capital spend per worker	Capital spend: Penn World Table Labour force, total: World Bank	Capital stock at current PPPs (in mil. 2017US$) divided by Labour force, total.	Maximum: 0.79 Minimum: 0.03 Mean: 0.33 Standard Deviation: 0.15 Observations: 540

The EEA is an extension of the European Union's single market which allows free movement of goods, capital, services, and people between member states (UK Government, 2014). The countries included in the EEA are mostly developed, high income countries. The average GDP per capita for EEA countries studied in this paper for 2019 was $38,151. The average life expectancy in 2019 for the same group of countries was 81 years which is over 8 years above the global average of 72.6 years for 2019 (Roser, Ortiz-Ospina and Ritchie, 2019). Over the period of 2002 to 2019, there has been an increase in both GDP per capita and life expectancy, shown for the EEA group studied by figure 2 and 3.

Figure 2 – Average GDP per capita

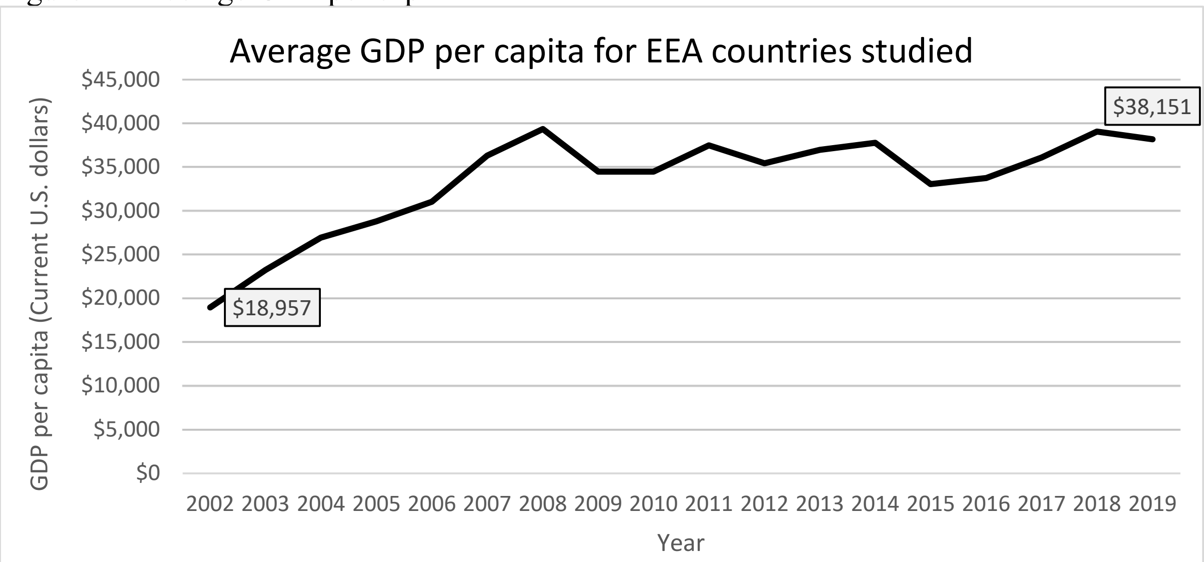
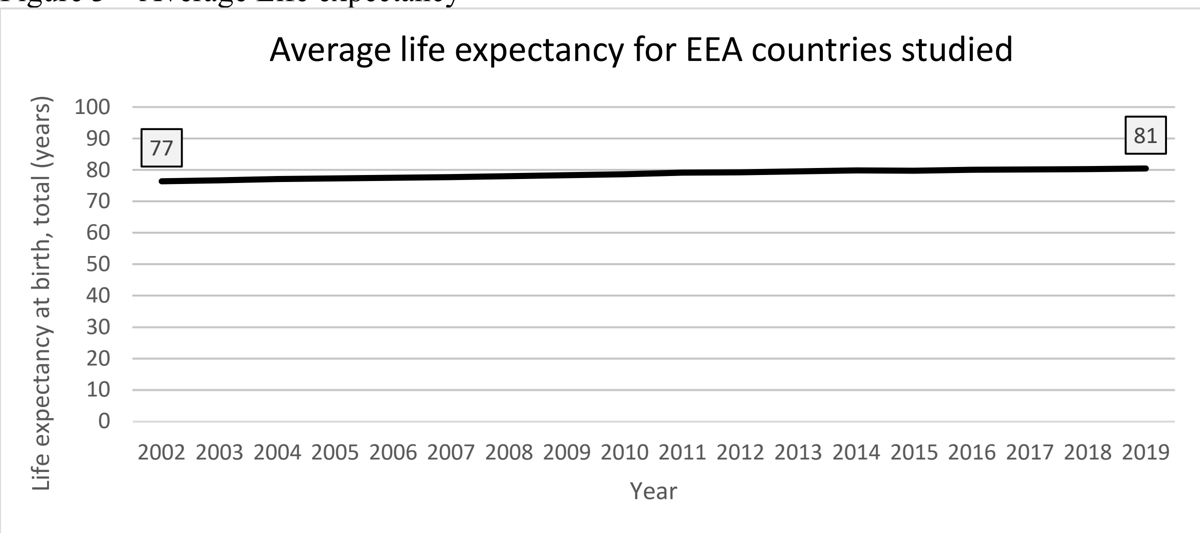


Figure 3 – Average Life expectancy



The correlation between GDP per capita and life expectancy is 0.65 indicating a moderate positive correlation. However, correlation does not always indicate causation and therefore panel data regression analysis is performed in the next section of this study to assess the causal effect of life expectancy on GDP per capita in a robust and meaningful manner.

Methodology – Regression models and robustness tests

To analyse if there is a statistically significant casual effect of life expectancy on GDP per capita for EEA over 18 years from 2002 to 2019, regression analysis was performed using econometric techniques.

The selected final model was the 2SLS model with time and entity fixed effects. The main reason for this model selection was to address the endogenous relationship between GDP per capita and life expectancy discussed in the literature and shown through the robustness model test results. The final model was selected through a range of statistical tests and follows a similar framework shown by Biyase (2019) and Hansen and Lønstrup (2015) who both employed a 2SLS fixed effects estimator to account for a possible endogeneity bias.

Firstly, to test the data to see if a unit root was present, the Augmented Dickey Fuller (ADF) test was run on all variables. The null hypothesis of the ADF test is that a unit root is present, meaning the data is non-stationary. The alternative hypothesis is that a unit root is not present, and the data is stationary. The ADF test results are based on the given P-values. For all variables used in this regression analysis the P-values were smaller than 0.05 which means the null hypothesis is rejected and there is no unit root present in the data. This is an important first step before completing regression analysis due to non-stationary data leading to unreliable and spurious results.

The next step in the analysis was to assess the normality of the data by creating histograms of the data in levels. The histogram for GDP per capita was skewed in level form and therefore throughout the analysis it is in log form. The other variables used in the regression displayed more normally distributed data and therefore are analysed in level form. This formation later impacts the interpretation of coefficients as the model will produce a log-level regression.

The Granger Causality test was then run to examine the endogenous relationship between life expectancy and GDP per capita. Granger Causality was tested in both direction with the null hypothesis stating that life expectancy does not cause GDP per capita (and vice versa that GDP per capita does not cause life expectancy) and the alternative hypothesis states that life expectancy does cause GDP per capita (and vice versa that GDP per capita does cause life expectancy). In both tests, the P-vales were below 0.05 meaning there is bidirectional causality. This means that life expectancy and GDP per capita both impact each other. Life expectancy is an endogenous independent within the model that later is accounted for to minimise biased results and isolate the casual impact of life expectancy on GDP per capita.

After running the prerequisite tests on the data, the regression model selection process started with a Pooled OLS specification. When analysing panel data, Pooled OLS regression is one of the simplest specifications and a starting point for lots of literature that uses panel data. It can be used as an informative model however it was shown to produced biased results for the data used in this study. The next model ran was the entity Fixed Effects model which controls for time-invariance differences between countries. The Fixed effects model specification controls for unobservable heterogeneity which is not accounted for in the Pooled OLS specification. An F-test was run for model selection to indicate the preferred model between the Pooled OLS model and the entity Fixed Effects model. The null hypothesis for the F-test was that Pooled OLS was preferred, whilst the alternative hypothesis was that Fixed Effects was preferred. The

P-value from this test was reported to be smaller than 0.05 meaning the null hypothesis is rejected and the entity Fixed Effects model is preferred.

Next a Random Effects model was modelled and compared the entity Fixed Effects model using the Hausman test for model selection. Unlike the Fixed Effects model, the Random Effects model assumes the variation across countries is random and uncorrelated with the predictor or independent variables included in the model. There are benefits of using both models and the decision can be made by the Hausman test for model selection where the null hypothesis is that the Random Effects model is preferred, and the alternative is that the Fixed Effects model is preferred. The P-value from this test was reported to be smaller than 0.05 meaning the null hypothesis was rejected and the entity Fixed Effects model was preferred.

It was then required to test the impact of time effects on the entity Fixed Effects model. The two-way model controls for unobservable factors that vary across time and countries oppose to just time invariant factors. Using an F-test to see if time had a significant impact, the null hypothesis was that there was no significance of time Fixed Effect and the alternative hypothesis stated that there was a significant effect of using time Fixed Effects. The test resulted with a P-value smaller than 0.05 which meant the null hypothesis was rejected and that time and entity Fixed Effects was the preferred model specification to proceed with.

Following this model selection, it was important to consider the data and what has been highlighted by the prerequisite tests. With the bidirectional causality between GDP per capita and life expectancy the time and entity Fixed Effect model would not have been sufficient as a final model. Without accounting for the endogeneity, life expectancy is correlated with the error term in the model, violating one of the main OLS classical assumptions.

Using the approach of Biyase (2019) to address the bidirectional causality, a 2SLS model with time and entity fixed effects was employed, using the lag of life expectancy as the instrumental variable that is uncorrelated with the error term. This method can be explained using two equations:

First stage regression:

$$\begin{aligned} Life\ Expectancy_{it} = {} & \beta_1 Life\ Expectancy_{\ it-1} + \beta_2\, Age\ dependency_{it} + \beta_3 Migration_{it} \\ & + \beta_4 Trade_{it} + \beta_5 Inflation_{it} + \beta_6 Inflation_{it} + \beta_7 Government_{\ it} \\ & + \beta_8 Investment_{it} + \beta_9 Population\ density_{it} + \beta_{10} Political\ stability_{it} \\ & + \beta_{11} Capital/labour_{it} + \lambda \mathrm{D_i} + \gamma \mathrm{T_t} + \nu\_it \end{aligned}$$

where GDP per capita is the dependent variable and life expectancy is the endogenous independent variable. Age dependency, migration, trade, inflation, government spend, investment, population density, political stability and capital spend per worker are exogenous control variables. The lag of life expectancy is the instrumental variable. λD_i is the entity fixed effect, γT_t = time fixed effect and ν_{it} = error term.

Second stage regression:

$$\begin{aligned} Log\ GDPpc_{it} = {} & \hat{}\beta_1 Life\ Expectancy_{\ it} + \beta_2\, Age\ dependency_{it} + \beta_3 Migration_{it} \\ & + \beta_4 Trade_{it} + \beta_5 Inflation_{it} + \beta_6 Inflation_{it} + \beta_7 Government_{\ it} \\ & + \beta_8 Investment_{it} + \beta_9 Population\ density_{it} + \beta_{10} Political\ stability_{it} \\ & + \beta_{11} Capital/labour_{it} + \lambda \mathrm{D_i} + \gamma \mathrm{T_t} + \nu\_it \end{aligned}$$

where $\hat{\beta}_1$ Life $Expectancy_{it}$ = the fitted values of Life expectancy obtained from the first stage regression, λD_i = entity fixed effect, γT_t = time fixed effect and again v_{it} is the regression error term.

The first stage regression uses the lag of life expectancy as the instrumental variable to estimate the impact of the exogenous control variables (Age dependency, migration, trade, inflation, government spend, investment, population density, political stability and capital spend per worker) on life expectancy while controlling for time and entity Fixed Effects. The fitted values of life expectancy created from the lag of life expectancy is then used as the explanatory variable in the second stage regression to estimate the causal effect of life expectancy on the log of GDP per capita, while also controlling for a set of exogenous control variables and the same fixed effects.

The inclusion of the lag of life expectancy in the first stage regression ensures that the life expectancy is no longer correlated with the error term in the second stage regression, making the coefficient estimates unbiased. The control variables in the second stage regression help to isolate the effect of life expectancy on the log of GDP per capita from other potential confounding factors. The fixed effects in both stages control for unobserved heterogeneity across countries and time.

The Cragg-Donald F-test for weak instruments was tested on the lag of life expectancy where an F-statistic value below 10 indicates a weak instrument. The F-statistic from this test was above 10 meaning the lag of life expectancy is uncorrelated with the error term and therefore the lag of life expectancy is a valid instrument.

To ensure robust results, tests for heteroskedasticity and serial correlation were undertaken using the Breusch Pagan Test and Durbin-Watson Test for each regression model. The null hypothesis for the Breusch Pagan test is that heteroskedasticity is not present and the alternative hypothesis is that heteroskedasticity is present. The P-value from the test reported to be lower than 0.05 meaning that the null hypothesis was rejected and heteroskedasticity is present. The null hypothesis for the Durbin-Watson test is that serial correlation is not present, and the alternative is that serial correlation is present. The P-value from the test reported to be lower than 0.05 meaning the null hypothesis was rejected and there is serial correlation. If heteroskedasticity is present the OLS classical assumption of the error term having constant variance is violated. If serial correlation is present, then the classical assumption of zero correlation between the errors is violated. To accounted for both heteroskedasticity and serial correlation, Arellano robust standard errors were applied which estimate the variance of the coefficients using different methods that account for the violation of the OLS classical assumptions.

Results and Discussion

As explained by the methodology, the final model aims to provide robust, unbiased and reliable coefficients that aid the analysis of causal impact of life expectancy on GDP per capita. The results from the final 2SLS model with time and entity fixed effects are shown by table 2.

Table 2: Results: The 2SLS model with time and entity fixed effects where Log_GDPpc is the dependent variable.

	coefficient	standard error	t value	p value	
Life expectancy	9.1233E-02	4.1776E-02	2.1838	0.029484	*
Age dependency	1.1586E-02	7.8181E-03	1.4820	0.139046	
Migration	2.0053E-07	1.0179E-07	1.9701	0.049435	*
Trade	-1.8220E-05	6.5976E-04	-0.0276	0.97798	
Inflation	-8.2974E-03	4.7488E-03	-1.7473	0.081267	.
Government Spend	-2.4492E-02	1.1454E-02	-2.1382	0.033032	*
Investment	1.3540E-02	4.8029E-03	2.8191	0.005026	**
Population density	2.3049E-04	4.4405E-04	0.5191	0.603974	
Political stability	2.0337E-03	1.4821E-03	1.3722	0.170692	
Capital/labour	-1.1041E-02	3.8014E-01	-2.9043	0.00386	**

Total Sum of Squares: 7.7896
Residual Sum of Squares: 5.6267
R-Squared: 0.28174
Chisq: 172.92 on 10 DF, p-value: < 2.22e-16

To interpret the coefficients correctly it is important to highlight that the independent variables are modelled in levels and the dependent variable is modelled in log form. To calculate the magnitude of the of the independent variables the methodology used by (Ford, 2018) was employed. The calculation follows the structure of finding the exponentiate the coefficient, subtract 1 from this number, and multiply by 100. The results are then given as a percent change in the GDP per capita for a one unit increase in the independent variable, shown in table 3.

Table 3: Calculation to account for log-linear interpretation

Variable	Coefficient	(to 1 significant figure)	1 unit increase of variables, Impact (% change) on GDP per capita
Life expectancy	9.12E-02	=(EXP(0.09)-1)*100	9.55
Age dependency	1.16E-02	=(EXP(0.01)-1)*100	1.17
Migration	2.01E-07	=(EXP(0.0000002)-1)*100	0.00002
Trade	-1.82E-05	=(EXP(-0.00002)-1)*100	-0.002
Inflation	-8.30E-03	=(EXP(-0.008)-1)*100	-0.83
Gov Spend	-2.45E-02	=(EXP(-0.02)-1)*100	-2.42
Investment	1.35E-02	=(EXP(0.01)-1)*100	1.36
Population density	2.30E-04	=(EXP(0.0002)-1)*100	0.02
Political stability	2.03E-03	=(EXP(0.002)-1)*100	0.20
Capital/labour	-1.10E-02	=(EXP(-0.01)-1)*100	-1.10

Assuming ceteris paribus when interpreting coefficients plays an important role as holding other factors fixed is critical for policy analysis to clearly identify the casual effect. Multiple control variables were used in this regression to hold constant these influential variables on GDP per capita to try and identify the causal effect of life expectancy on GDP per capita.

Life expectancy

The results from the 2SLS model with time and entity fixed effects shown in table 2 report that life expectancy has a statistically significant positive effect on GDP per capita at a 5% significance level. Using the formula mentioned above a 1-year increase in life expectancy, increases GDP per capita by 9.6% for the EEA countries studied between 2002-2019. Due to the underlying conditions of the 2SLS model, the impact of life expectancy on GDP per capita is showing the fitted values of life expectancy once the model has controlled for endogeneity by removing the effect that GDP per capita has on life expectancy.

The result of this study adds to the literature in multiple ways. Firstly, it provides a result for countries within the EEA which has previously not been investigated. There are studies on advanced economies including the work of Sharma (2018), Swift (2011) and Neofytidou and Fountas (2020) but none of which investigate the EEA or EU. The results from this study also add to the literature in support of health having a statistically significant impact of on economic growth. Other studies analysed within the literature review that evidence this relationship include: Ridhwan (2022) who assess 64 studied, Swift (2011), Sharma (2018), Bloom (2019) concluding from both microeconomic and macroeconomic findings, Barro (1996) and Biyase (2019).

The magnitude of the effect that life expectancy has on GDP per capita fluctuates across the literature as it is dependent on countries studies, time period selected and other variables used within the regression. Neofytidou and Fountas (2020) found a similar result for 19 developed countries from 1950 to 2013. They reported that a 1% increase in life expectancy leads to an 8.32% or 8.36% increase in GDP per capita using different regression analysis techniques to generate both findings. Bloom (2001) also reported similar findings from 104 countries from 1970 to 1990, stating that a 1-year increase in life expectancy leas to a 4% increase in GDP.

Linking the results of the empirical analysis to the theoretical framework of health being an influential factor for human capital, the gain in GDP per capita can be explained by numerous factors mentioned earlier on in the paper, some of which include; increased productivity and reduced absenteeism and presenteeism, higher labour market participation rates which is associated with lower unemployment and increased capital flows, increased ability and incentive to improve education and skills and reduced healthcare expenditure for both prevention and curative healthcare. Highlighted by the coronavirus pandemic, good health also prevents significant economic disruption from disease and infection.

Migration

The results shown in table 2 report that net migration has a statistically significant positive effect on GDP per capita at a 5% significance level. Using the formula mentioned above an increase in net migration of 1 person would yield an increase in GDP per capita of 0.00002%. In a more meaningful manner, an increase of 1000 immigrants into a country would increase that countries GDP per capita by 0.02%.

This positive relationship can be explained through increased labour supply and improve innovation through the transfer of knowledge and skills. The report written by Commonwealth of Australia (2006) discusses the positive impact of migration. They highlight the impact of migration on demographics, labour supply, productivity and innovation and described immigration as a "crucial role in shaping the economy".

<u>Inflation</u>

The results shown in table 2 report that inflation has a statistically significant negative effect on GDP per capita at a 10% significance level. Using the formula mentioned above a 1 percentage point increase in inflation (such as from 3% to 4%), decreases GPD per capita by 0.83%. Inflation can be damaging for economic growth for many reasons. The EEA aims for inflation to be around 2% each year which is reported to be the best rate to maintain price stability (European Central Bank, 2019).

Akinsola and Odhiambo (2017) assesses the relationship between inflation and economic growth in developing and developed countries. They evidence a strong negative relationship between inflation and growth, particularly for developed economies. The paper discusses how high inflation causes the value of money to decrease over time and therefore reduces purchasing power. Monetary policy is one way of controlling for high inflation by increasing the interest rate, however this can lead to increased saving and less borrowing in the economy which can affect economic growth.

<u>Government Spend</u>

The results shown in table 2 report that government spending has a statistically significant negative effect on GDP per capita at a 5% significance level. Using the formula mentioned above, if government expenditure as a percentage of GDP rose by a 1 percentage point increase (for example from 15% to 16%), GDP per capita would decrease by 2.42%. Government spending includes all current expenditures for purchases of goods and services including compensation of employees. This negative relationship was also reported by Landau (1983) who uses the same metric for government expenditure. The negative relationship could be a result of this metric not covering all aspects government expenditure.

Grossman (1990) discusses that government spending can have a negative impact on economic growth due to factors including misallocation of resources and inefficiency. The government does not operate in the same way as a business in terms of having a profit incentive, this can mean some expenditure decisions can be inefficient and not cost effective. This relationship may also be negative if economic growth is not the main aim of government expenditure. The government's role can include improving standard of living and equality.

<u>Investment</u>

The results shown in table 2 report that investment has a statistically significant positive effect on GDP per capita at a 1% significance level. Using the formula mentioned above, an increase in investment as a percentage of GDP by 1 percentage point (for example from 10% to 11%), increases GDP per capita would increase by 1.36%. There are multiple reasons that explain how investment increases economic growth.

The review of public and private investment by Makuyana and Odhiambo (2017) shows that both play a significant role in economic growth with private investment having a higher impact when compared empirically. Investment is considered a crucial element of economic growth using the framework:

GDP = Consumption + Investment + Government Spending + Net Exports

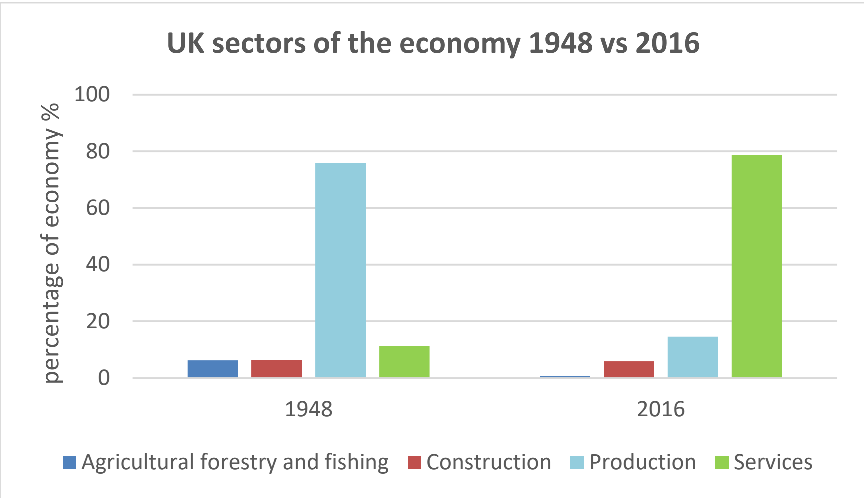
Investment creates employment, innovation through research and development, increase productivity and efficiency and can create multiplier effects that drive economic growth.

Capital/labour

The results shown in table 2 report that capital spend per worker has a statistically significant negative effect on GDP per capita at a 1% significance level. An increase in the capital stock of $1 million divided by the labour market would result in a decrease in GDP per capita by -1.10%. This negative relationship can be explained by de-industrialisation.

The industrial revolution created a huge increase in physical capital to aid human capital in creating goods. Since then, there has been significant advances over time in technology and how the economy operates, more so in recent years. For example, the UK's sectors of the economy from 1948 and 2016 show a large shift from being production dominant to service dominant as seen on figure 3. Excessive spending on physical capital for these developed countries could cause a misallocation of resources or cause diminishing marginal returns.

Figure 3: UK sectors of the economy change over time



Data:(ONS, 2016)

Other control variables

Variables that did not show statistical significance in the model include the age dependency ratio, net trade, population density and political stability however these impacted the overall fit of the model and so were kept in. These variables are still important factors of economic growth but are not highlighted within this study. Average years in schooling and the percentage of the population that are female were both tested in the model but removed due to collinearity which approach was also taken by Sharma (2018) who also assess developed economies.

Project Outcomes: Conclusion and Recommendations

This dissertation used regression analysis and econometric techniques to assess the macroeconomic relationship between health and economic growth. The study accepts the hypothesis that health (represented by life expectancy from birth) has a statistically significant positive effect on economic growth (represented by GDP per capita) for countries within the European Economic Area (EEA) from 2002 to 2019.

The main finding from the 2SLS model with time and entity fixed effects is that life expectancy has a statistically significant positive effect on GDP per capita at a 5% significance level. A 1-

year increase in life expectancy, increases GDP per capita by 9.6% for the EEA countries studied between 2002-2019. Due to the underlying conditions of the 2SLS model, the impact of life expectancy on GDP per capita shows the fitted values of life expectancy once the model has controlled for endogeneity.

The result of this study adds to the literature by evidencing the relationship between health and economic growth for countries within the EEA which has previously not been investigated. There are studies on advanced economies including the work of Sharma (2018), Swift (2011) and Neofytidou and Fountas (2020) but none of which investigate the EEA or EU. The results from this study also add to the literature in support of health having a statistically significant impact of on economic growth, as shown by Ridhwan (2022), Swift (2011), Sharma (2018), Bloom (2019), Barro (1996) and Biyase (2019).

The magnitude of the effect that life expectancy has on GDP per capita fluctuates across the literature as it is dependent on countries studies, time period selected and other variables used within the regression. Neofytidou and Fountas (2020) found a similar result for 19 developed countries from 1950 to 2013. They reported that a 1% increase in life expectancy leads to an 8.32% or 8.36% increase in GDP per capita using different regression analysis techniques to generate both findings. Bloom (2001) also reported similar findings from 104 countries from 1970 to 1990, stating that a 1-year increase in life expectancy leas to a 4% increase in GDP.

Linking the results of the empirical analysis to the theoretical framework of health being an influential factor for human capital, the gain in GDP per capita can be explained by numerous factors. Health directly effects ability, productivity, and well-being of individuals, therefore impacts labour market participation and worker productivity (Tompa 2002). Productivity effects can be explained by lower rates of absenteeism and presentism, which refer to sickness absence and illness whilst working. Healthy individuals are more likely to be part of the labour force, generate a salary and contribute to the economy. This also benefits the economy through increased ability and incentive to improve education and skills which creates lower unemployment rates and increased government revenue. Good health also reduces healthcare expenditure and prevents significant economic disruption from disease and infection.

The empirical analysis from this study also shows statistical significance for the impact of migration, inflation, government expenditure, investment and capital spend per worker on GDP per capita that follow patterns seen throughout the literature.

This research further supports the literature which further illustrates the importance of good public health on economic growth using macroeconomics and econometrics. The findings may influence EEA policy makers as they reflect the importance of a healthy population. This may lead to potential policy effects including increased health expenditure, the creation or adoption of policies to improve public health and further analysis on human capital impacts of mortality and morbidity.

In 2019 EEA countries spent around 8.4% of GDP on healthcare which was above the world average (World Bank, 2019). With opportunity costs associated with every government financial decision, improving public health and reducing the costs of healthcare in the future will allow for government expenditure to be spent on other important factors that influence long term growth such as infrastructure, education and research and development projects.

Investments in public health include both prevention and curative healthcare. Policies such as advertising and promotions policy restrictions, nutrition labelling, sin taxes and healthy food schemes play an important role in promoting better health to prevent poor health, whilst investment in better healthcare technology and new medicine improves healthcare provision to cure healthcare conditions.

There are limitations to this study including not having a full set of EEA countries as there was not all data available on Liechtenstein. Another limitation to this study is that health is approximated by life expectancy which measures longevity oppose to quality of life or the direct physical and mental health of the working age population. Whilst life expectancy is repeatedly used in the literature and a good indicator of health, there is scope for further research using different measures of health.

Future research recommendations to build on this area of research should focus on morbidity over mortality, which measures prevalence of illness or disease oppose to death rates. This should indicate a better health status of the working age population. A focus on specific areas of health would also be of interest to policy makers including investigating the effect of increasing rates of obesity on labour market participation. One final recommendation would be to assess how useful government interventions around health are, such as sin taxes and nutrition labelling.

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