Norwegian School of Economics,
Bergen, Autumn 2020

Historical Index of Human Development on Scandinavian Countries 1820-2020

Construction and Interpretation

Daniel Valen Grytten

Supervisor: Bjørn L. Basberg

MSc in Economics and Business Administration

Major profile: International Business (INB)

Norwegian School of Economics

Acknowledgements

This thesis has been written as a part of the MSc in Economics and Business Administration at the Norwegian School of Economics. Having spent five years studying this field I have finally discovered how little I actually know. This time has had its impact on me, my friends, family and others who are close to me.

First, I have to give thanks to God and my family for being present with me, guiding me and for putting up with me through these five years and especially these last six months. Especially, I would like to thank my father; Ola Honningdal Grytten for guiding and helping me with the theme, methods, literature and all the other ways he assisted me through this task and study.

Another person deserving of gratitude for this thesis is Bjørn Lorens Basberg, my supervisor. He has guided the structure and provided vital feedback throughout the course of this project. I want to especially thank him for being available to help whenever I have been in need of it.

My gratitude also is directed towards Leandro Prados de la Escosura, the creator of the Historical Index of Human Development, who provided me with data, literature and guidance on his field and research. I would have struggled accomplishing this on time without his help. In a forthcoming publication he will launch an updated version of this index accounting for political factors.

Also, I would like to thank my two American friends Luke Jennen, Madeline Barinowski and Amanda Sødal. Luke for helping me sharpen the language of this thesis. Madeline, for enhancing my vernacular as well as always being there for me whenever in need of her support. Amanda, I want to thank for reading through the thesis and aiding me with my language.

At last I want to thank all my friends for help and support through this time and the library at the Norwegian School of Economics for helping me identify literature and information.

Abstract

This thesis calculates and analyses wealth through the Historical Index of Human Development, which is constructed to account for both economic (GDP per capita/income) and social variables (life expectancy/health and education). Through three research questions we explore and analyse: (1) what the human development levels were for Denmark, Norway and Sweden from 1820 to 2020, with 2019 being our last year for our time series. (2) How well economic growth reflects human development. (3) How much each parameter of the HIHD contribute to its development.

To analyse these questions we (1) construct the HIHD by first calculating the indices for income, health and education for our time period in question. This we analysed through a comparative analysis where we found that: all Scandinavian countries were at least at the OECD average in the 19th and 20th century and that among these Denmark and Norway were above this average while Sweden was around it. Additionally, we discovered that Norway and Denmark were at more or less the same level during the 19th century. During the 20th century all three countries outpaced the average of the wealthy OECD. The short run development was significantly more uniform between Sweden and Norway than between Denmark and Norway. Further, we (2) conducted a quantitative analysis of the relationship between GDP per capita in fixed prices and the HIHDs for Denmark, Sweden and Norway finding that there is a high correlation between the long term HIHD and GDP per capita. That the short term corelation is not as strong as the long-term, due to larger fluctuations in GDP than HIHD. We also found that GDP per capita does not reflect human development to a satisfactory degree and, therefore, also fails at reflecting living standard and economic development. Finally, we (3) analyse GDP, education and life expectancy's relative weights in annual HIHD series which helped us deduce that GDP per capita is the most important contributor to HIHD, but it declines in importance over time. Education was and is the second largest contributor with its contribution increasing moderately. Life expectancy was and is the lowest contributor, however, its contribution doubled from 1820 to 2019. Norway's surprisingly well performance during the 19th century is largely due to their high life expectancy rates. Sweden was clearly inferior to Denmark and Norway in writing skills during the first half of the 19th century, which made their HIHD fall relative to their Scandinavian neighbours.

Abbreviations

HDI – Human Development Index

HIHD – Historical Index of Human Development

GNI - Gross National Income

GDP – Gross Domestic Product

PPP – Purchasing Power Parities

UNDP – United Nations Development Programme

CFI – Corporate Finance Institute

HP-filter - Hodrick-Prescott Filter

OECD – The Organisation for Economic Co-operation and Development

G-K Dollars – Geary-Khamis Dollar

HIHD VJM – Historical Index of Human Development Vannebo Johansson Markussen

HIHD EF – Historical index of Human Development Escosura Flora

Foreword

My father, Ola Honningdal Grytten, first piqued my interest in the Human Development Index and the Historical Index of Human development. He also pointed out that there were no reliable calculations previous to 1870. Thus, calculating them further back would be a yet unexplored theme and valuable learning experience of how research is conducted within the field of historical economics. In addition, he has done extensive research in the field of historical wealth among the Scandinavian countries and has often told me that Norway did quite well, a bit inferior to Denmark, but better than Sweden. Having this in mind it is worth mentioning that further references to Grytten are a reference to him and not any of my previous works.

Therefore, I once again want to show him my gratitude.

Table of Contents

1. Introduction

1.1 Theme and Background

Writers on Scandinavian Economic history often question the relative historical wealth of Denmark, Norway and Sweden. According to Grytten Norway did quite well, a bit inferior to Denmark, but better than Sweden. However, Norwegian school curriculum tends to teach us differently, namely that Norway was a poor country during the 19th century. During my studies at the Norwegian School of Economics, I discovered scholars have differing opinions on this subject. Hence, having encountered this question and its debate for years, I decided to investigate it myself.

In the light of Norway's achievement, I also deemed it beneficial to compare similar numbers for its two closest neighbours, specifically Sweden and Denmark. Having in mind that there were no reliable calculations for HIHD previous to 1870, calculating them further back would be an unexplored theme and a valuable learning experience of how research is conducted within the field of historical economics.

The Human Development Index (HDI) was created to measure a country's achievements through economic and social dimensions and is thought of as being a broader alternative to GDP per capita. However, few of the available time series one finds for HDI go further back than 1970. However, in 2014 Leandro de la Escosura published an article in which he calculated the Historical Index of Human Development (HIHD) (Escosura, 2014). This measure is based on the HDI and is better suited to calculate human development further back in time. Since Escosura is the leading researcher in the field, I decided to use his method for calculations of historical human development.

1.2 Definitions

Further, in our research we need to define what we are investigating. Therefore, in this section we will define some of the main terms in use in this thesis.

1.2.1 Human Development Index (HDI)

The Human Development Index (HDI) is the most important part of the Human Development Report by the United Nations Development Program (UNDP). It is first and foremost a statistical tool used to measure a country's achievements through social and economic dimensions. It utilises social variables as well as economic ones. It was created by the Pakistani economist Mahbub ul Haq as a way of assessing human development (Bennett, Coleman & Co, 2020). It is a method of measuring wealth by different measures than pure economic ones. It assesses the following three key dimensions, measured by three indicators (Roser, 2014):

1. A long and healthy life, longevity and/or health (dimension)
    a. Life expectancy at birth (indicator)
2. Knowledge and/or education (dimension)
    a. Expected years of schooling (indicator)
    b. Mean years of schooling (indicator)
3. A decent standard of living and/or income (dimension)
    a. Gross National Income per capita in purchasing power parities (indicator)

Knowledge and a long and healthy life are social variables while a decent standard of living is an economic dimension. Further details of these dimensions will be discussed more thoroughly in the theory section.

Further, human development can be defined as:

"A process of enlarging people's choices and freedoms to live long, healthy and creative lives; to advance other goals they have reason to value; and to engage actively in shaping development equitably and sustainably on a shared planet." (Milorad Kovacevic, 2019).

The United Nation's Human Development Report states that the HDI was created to emphasise that people and their capabilities should be an ultimate indicator when assessing a country's development, not solely economic growth. Hence, one can analyse how countries with the same level of GNI can end up with different human development outcomes. This is how the HDI can be used to question choices within national policy. Therefore, HDI does not solely measure economic performance, but rather how human development performance is invested in the people, and how this investment enlarges their freedom and choices.

1.2.2 Historical Index of Human Development (HIHD)

The Historical Index of Human Development (HIHD) is a measure of human development. It was created by Leandro Prados de la Escosura. It provides an index measured across the same three dimensions as for the HDI focusing on human wellbeing as something more than just the income (Espacio Investiga, 2019; Roser, 2014). This implies enlarging people's choices to enjoy a healthy life, acquire knowledge and achieve a decent standard of living.

The indicators in the HIHD are expressed slightly differently from the HDI. The difference stems from a lack of sufficient historical data to calculate HDI if the same dimensions are utilised. Therefore, to get a historical view of HDI the following dimensions are used:

1. A long and healthy life and/or longevity (dimension)
    a. Life expectancy at birth (indicator)
2. Knowledge and/or education (dimension)
    a. School enrolment (indicator)
    b. Literacy (indicator)
3. A decent standard of living and/or income (dimension)
    a. Gross Domestic Product per capita in purchasing power parities (indicator)

The first two points, life expectancy and education, are considered social variables while the last is chiefly an economic variable.

1.3 Research problems

Despite already having numbers for HIHDs we believe these numbers can be updated. Also, we acknowledge the broad and large project of calculating this index for all countries in the world and therefore by only focusing on a few countries one can derive more accurate numbers. These might give us insight not only into human development, but also the relationship between human development and economic growth and the relative importance of the human development parameters, GDP per capita, education and life expectancy.

Hence, the research problem of this thesis is threefold:

1. What were the human development levels for Denmark, Norway and Sweden from 1820 to 2019?

   This question is answered by constructing new and revised annual series of HIHD and its components for the period in question.

2. How well does economic growth reflect Human development?

   This question is answered by a quantitative analysis of the relationship between GDP per capita in fixed prices and the HIHDs for Denmark, Sweden and Norway

3. How much do the parameters of the HIHD contribute to its development?

   This question is answered by a quantitative analysis of GDP, education and life expectancies relative weights in annual HIHD series.

By examining these research problems, we will conduct a comparative analysis comparing the new indices to those of important regions of the world and existing indices for Norway, Sweden and Denmark.

The first research problem demands huge sets of data, and the construction of novel historical series implying that this section of the thesis is by far the most time and space consuming.

1.4 Limitations

The reason for choosing the period 1820 to 2019 is data availability. All relevant, valid and reliable data sources start around this decade. Also, they only allow us to calculate HIHD and not HDI. The GDP series are already calculated by other scholars, and the life expectancy data can be found in the national statistical offices of the three countries. However, when it comes to education, i.e., literacy rates and enrolment rates, novel series are presented here, calculated on the basis of limited benchmark year data. This makes the educational series less reliable than the other parameters during the 19th century.

1.5 Structure of Thesis

This thesis first takes us through an introduction whereby we identify our theme and its background. Thereafter, we explain our main definitions before we identify our research questions. We finish chapter one of by stating limitations of the thesis.

Chapter two is about literature and theory. It introduces the international research done on HIHD followed by research done on Norway, Sweden and Denmark. Then we explain the neo-classical Solow-Swan growth model as a foundation for growth models, including the HIHD. Last, we introduce and explain the components and dimensions of both the HDI and the HIHD.

In chapter three we will introduce our model. We here explain how the calculations are done for both HDI and HIHD. Chapter four presents the different data for Denmark, Norway and Sweden, which we use for each of the HIHD's three dimensions; Income (GDP per capita), health (life expectancy) and education (literacy rates and school enrolment rates). Also, we explain where we retrieved the data, how we construct our time series and how we intend to use them. Further, chapter five explains how we calculate each index and eventually our HIHD data series. It also presents the development of our results.

Chapters six through eight present the main analysis of the newly established HIHDs and their components. In chapter six we conduct a comparative analysis between our findings and the previous findings of Escosura for different world regions and Scandinavia. Further, we also compare the growth of our own datasets to one another comparing the growth between Denmark, Norway and Sweden. Chapter seven analyses the relationship between GDP per capita and HIHD. Here we try to understand the GDP's effect and how indicative a measure it is for wealth and development. In chapter eight we identify the contribution of each dimensions and their developments through the period 1820 to 2019.

Finally, in chapter nine we present the summary, findings and their implications. Some of these suggest we have to revise some of our understandings of relative Scandinavian development in the 19th century, suggesting Norway was at the same level as Denmark (above the OECD level) and Sweden outperformed our expectations as well (being about the same level as the OECD). Our main conclusions are that Norway was at the same level as Denmark in human development already at the 19th century. Also, they were above the OECD average. Sweden was at the OECD level. This places both countries higher than assumed on the basis on GDP per capita figures only. GDP per capita is the most important contributor to the HIHD, but its importance is declining. Life expectancy has the lowest contribution but shows the most significant increase.

Finally, we present our referenced literature, sources, and appendices. The appendices will contain all our numbers for the different HIHDs, the indices for each dimension and the rates for literacy, school enrolment, GDP per capita and life expectancies which we used to calculate the indices.

2. Literature and Theory

2.1 International Research on HIHD

In 2015 Escosura published his groundbreaking research paper entitled *World Human Development: 1870-2007*[1]. This focused on his method of calculating HIHD and the results he extracted from his research and calculations.

The paper presents HDIs back to 1870 calculated by the same method as done in the HDI by the United Nations Development Program (Escosura, 2015). Its difference from the HIHD derives from the way in which the original values of the social variables are transformed and from the aggregation function used by stretching HDIs, based on fixed weights that long back in time make them unrepresentative of the historical development (Escosura, 2015). Thus, we need a more dynamic approach, which is found in the HIHD as calculated by Escosura.

Escosura concludes that substantial, but incomplete gains in world human development has taken place. Based on the research of Escosura, it seems like the gap between the OECD and the rest of the world is widening. For years longevity, i.e., life expectancy, was the leading factor of growth among the OECD countries and a vital factor for them forging ahead. This is an indicator of the quality of life being higher among the OECD countries than the rest of the world. The rest of the world's catching up has mainly been seen in the GDP series. However, the last four decades have seen education rise to become the factor playing the most decisive role in the divergence between countries with high or very high HIHD and countries with lower HIHD values (Escosura, 2015).

Wellbeing improved intensively during the last one and a half century. There was significant progress in longevity and education. It seems that public policies have played an important role in the improvements of health and education. Also, technological and medical change seems to have been a major contributor to health and life expectancy.

The improvement of life expectancy, or longevity, should be considered a vital indicator to the wellbeing of society, given the assumption that a nation's population speaks to the overall health of the society's economic performance. Therefore, it often reflects economic growth and

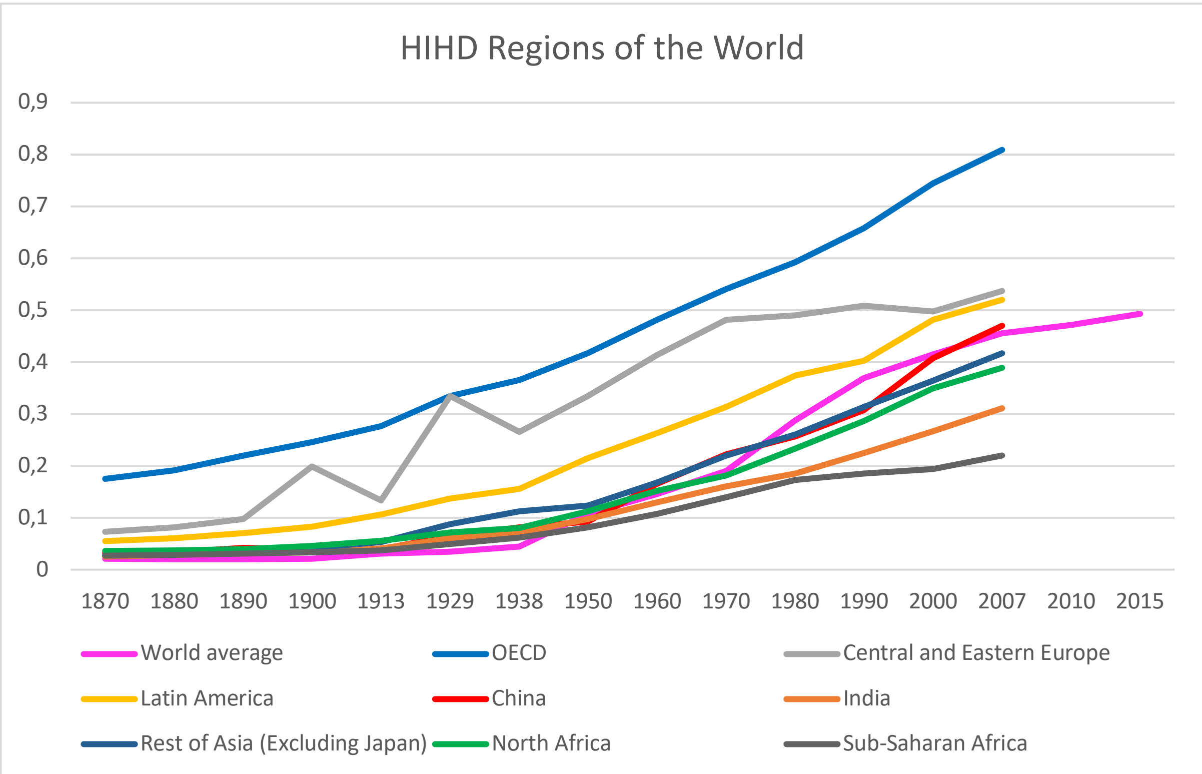
[1] The Review of Income and Wealth. Series 61, Number 2, June 2015. DOI: 10.1111/roiw.12104. Universidad Carlos III and CEPR.

a high GDP. However, a high GDP does not necessarily always correlate well with the HDI or HIHD. According to Escosura this is often due to public policy, which is important for improvement in health and education (Escosura, 2014). Thus, it is important that the growth in GDP is spent socially on the population to acquire better living conditions.

Public policies are often determined by political systems. Socialist states seemed, according to Escosura, to fail to sustain their momentum and, with an exception from Cuba, stagnated and fell behind before the demise of socialism (2015). Also, other totalitarian regimes seem to suppress freedom and, thus, prevent real achievements in human development.

Figure 2.1 and table 2.1 demonstrate the development of the HIHD for different regions of the world according to Escosura:

Figure 2.1: HIHDs of Escosura from 1870-2007 and a world average from 1870-2015.



(Escosura, 2015; Espacio Investiga, 2019).

Table 2.1: HIHD for regions of the world and world average.

	World average	OECD	Central and Eastern Europe	Latin America	China	India	Rest of Asia (Excluding Japan)	North Africa	Sub-Saharan Africa
1870	0,021	0,175	0,073	0,055	0,032	0,025	0,028	0,036	0,027
1880	0,02	0,192	0,082	0,06	0,033	0,029	0,031	0,037	0,029
1890	0,02	0,22	0,097	0,071	0,042	0,034	0,037	0,04	0,031
1900	0,021	0,246	0,199	0,083	0,04	0,035	0,042	0,046	0,034
1913	0,031	0,277	0,133	0,106	0,04	0,041	0,053	0,056	0,037
1929	0,035	0,334	0,334	0,137	0,064	0,06	0,088	0,072	0,05
1938	0,045	0,366	0,266	0,156	0,081	0,07	0,113	0,08	0,062
1950	0,108	0,417	0,335	0,215	0,093	0,097	0,123	0,112	0,081
1960	0,146	0,482	0,413	0,263	0,166	0,13	0,168	0,152	0,108
1970	0,19	0,541	0,482	0,313	0,222	0,16	0,22	0,182	0,139
1980	0,288	0,593	0,49	0,374	0,257	0,185	0,261	0,233	0,173
1990	0,369	0,658	0,509	0,403	0,308	0,225	0,314	0,286	0,185
2000	0,415	0,745	0,497	0,481	0,408	0,267	0,364	0,35	0,194
2007	0,456	0,809	0,537	0,52	0,47	0,311	0,417	0,389	0,22
2010	0,472								
2015	0,493								

(Escosura, 2015; Espacio Investiga, 2019).[2]

These numbers illustrate the development and differences across the regions of the OECD countries, central and eastern Europe, Latin America, China, India, Asia excluding Japan, North Africa and Sub-Saharan Africa. We can see that the OECD countries reside far above the rest of the world. Central and Eastern Europe seem to have declined and then picked up growth again, with Latin America almost having caught up. Further, we can see China catching up to the regions mentioned above, reaching just above the world average. All other regions seem to be increasing, as is the divide between the OECD countries and the other regions.

Roser (2014) plots the HIHD relative to the average income, or GDP per capita. He discovers that there is a strong correlation with richer countries having a higher HIHD. This happens because income is in itself one of the three dimensions measured by the HIHD and partly because the other two dimensions are correlated with GDP per capita (Roser, 2014).

Further, he analysed the correlation between GDP per capita and HIHD without the income dimension (GDP per capita). He finds that overall there is a strong correlation between the HIHD measured with and without GDP per capita as an additional metric (Roser, 2014).

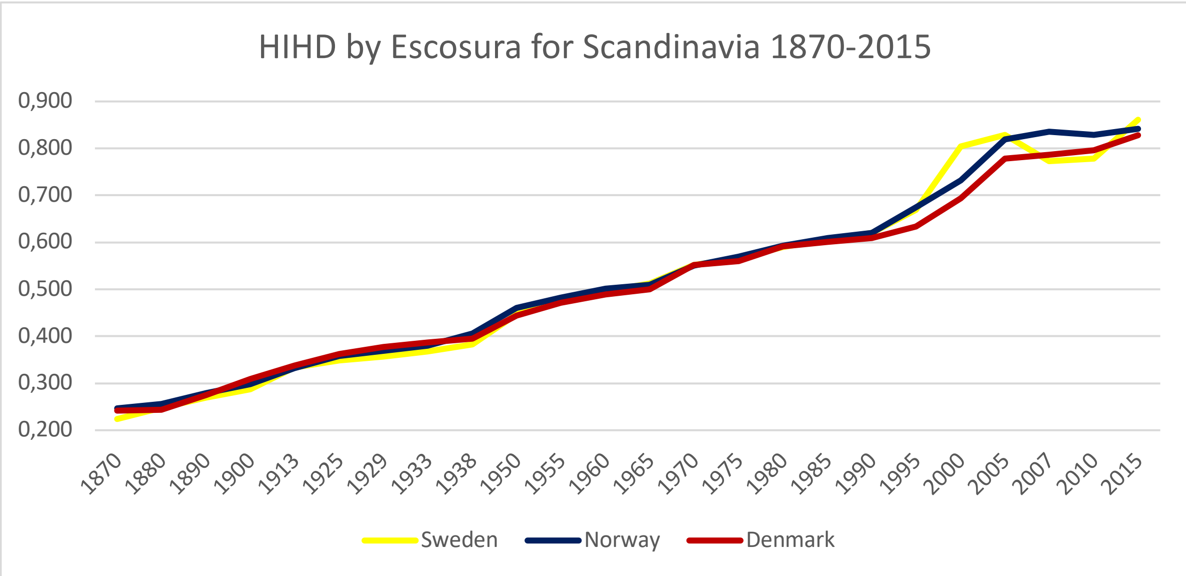
Finally, Roser compares HDI to HIHD where he finds that the latter tends to score lower than the former. Also, looking at changes over time shows the HIHD values to be lower than that of the HDI, and change faster since the indices are derived non-linearly, on a logarithmic scaling (Roser, 2014).

[2] The world average is retrieved from Espacio Investiga, while the rest are retrieved from Escosura's (2015) paper "World Human Development: 1870-2007" which is found in the *Review of Income and Wealth series 61 number 2.*

2.2 Research on Scandinavian HIHD

The existing HIHD calculations for Scandinavia are also done by Escosura (2019)[3]. For Denmark, Norway and Sweden he reports the following development depicted in figure 2.2.

Figure 2.2: HIHD by Escosura for Scandinavia 1870-2015.



(Espacio Investiga, 2019)

[3] The majority of Escosura's HIHDs are retrieved from the web page Espacio Investiga.

Table 2.2: HIHD by Escosura for Scandinavia 1870-2015

	Sweden	**Norway**	**Denmark**
1870	0.224	0.247	0.242
1880	0.248	0.256	0.243
1890	0.269	0.279	0.275
1900	0.287	0.298	0.309
1913	0.334	0.332	0.338
1925	0.348	0.358	0.362
1929	0.356	0.369	0.377
1933	0.368	0.380	0.387
1938	0.383	0.406	0.395
1950	0.447	0.460	0.443
1955	0.481	0.483	0.471
1960	0.497	0.502	0.489
1965	0.512	0.510	0.500
1970	0.552	0.550	0.552
1975	0.566	0.570	0.561
1980	0.590	0.593	0.591
1985	0.606	0.609	0.601
1990	0.621	0.621	0.609
1995	0.669	0.674	0.633
2000	0.805	0.732	0.694
2005	0.829	0.819	0.779
2007	0.773	0.835	0.787
2010	0.779	0.829	0.796
2015	0.861	0.842	0.828

(Espacio Investiga, 2019)

Escosura did estimations for most countries around the world. However, they rarely date any further back than 1870. By the numbers we can see that the three countries seem to follow one another rather closely. From around 1985 they do not follow each other as closely as previously. However, they have mostly equal trends and fluctuations.

2.3 Other Literature on Wealth and Human Development

The existing alternative literature to Escosura draw their conclusions on the basis of historical GDP per capita in PPP.

Bairoch (1976, p. 307) constructed the decadal PPP estimates of 19 European countries for the 1830-1973. According to him, Norway was the wealthiest Scandinavian country during the nineteenth century but was passed by Denmark in 1913. Sweden was significantly poorer.

However, Bairoch's calculations on PPPs and GDPs have been heavily criticised. Two years earlier Olle Krantz and Carl-Axel Nilsson published calculations for Norway, Denmark and Sweden. They adjusted historical national accounts with purchasing power equivalents and could therefore compare GDP per capita in terms of PPP for the Scandinavian countries. They conclude that Denmark had the highest GDP per capita in 1873. Further, they claimed that the GDP per capita for Norway were 90 percent of that of Denmark and that Sweden's were 57.6 percent of that of Denmark. In 1927 it had increased to 81.4 percent for Sweden and decreased to 78.6 percent for Norway (Krantz, 2001, pp.12-27).

In 1983 and 1984 Nicholas Crafts released new calculations for 17 European countries. He presented figures for Norway, Sweden and Denmark from 1860-1910. His estimates were in 2004 represented as the "final say" in this matter and they were taken by many economic historians as the most representative figures (Grytten, 2004). Crafts indicate that Denmark was the best among the Scandinavian countries over the entire period. Norway was the runner-up until 1900 with Sweden taking over its position from there on. Sweden was closing in the gap with Denmark (Crafts, 1983a, p. 389; Crafts 1983b, p. 440).

Crafts' estimates are based on PPP calculations made by Kravis and associates. Crafts extrapolated the PPPs backwards by adopting volume indices of GDP per capita. For 1910, in 1970 US dollars, he arrived at 1,050 US dollars for Denmark, 763 US dollars for Sweden and 706 US dollars for Norway (Crafts, 1983a, p. 389).

Maddison gathered various GDP series for different countries around the world. However, these numbers often have been calculated through the use of different methods, sources and definitions. Therefore, other historical economists have tried to make the numbers more unambiguous. Among these are Paul Bairoch and Nicholas Crafts, which we mentioned above, that did these calculations from the 17th century and the first part of the 18th century. These calculations show that Norway's GDP per capita was around the western European average in 1910 (Grytten, 2016). This they did by calculating purchasing power parities (PPP) where GDP for each country are adjusted based on different price level and currency rates. Thereafter, GDP is calculated into a common currency and price level.

Further, Grytten[4] spliced the GDPs with developments forward and backwards in time. This way he could compare Norway to the other western European countries. He found that the long-term wealth for Norway and Western Europe were rather similar up until the 1970s. Thereafter, Norway diverged and surpassed its neighbours. He gives the credit to its petroleum revenue. He also concludes that Denmark had higher GDP per capita in PPPs in the 1800s than Norway, while Norway had higher than Sweden (Grytten, 2016).

2.4 Theory: Neo-Classical Growth

Since the Historical Index of Human Development is used to describe human development, one seeks to explain the development through growth. Thus, we need a model that reflects a clear relationship with the HIHD and its variables; GDP per capita (income), education and life expectancy (health). Therefore, we will apply the Solow-Swan model, a version of the neo-classical growth model, to illustrate this connection. It is constructed on the basis of the production factors; ideas, capital, labour and education. We believe these variables to have the needed direct effect, relationship and/or reflection we are looking for.

The Solow-Swan model can be linked to the HDI in certain areas. However, while the HDI and HIHD measures education as a way of expanding one's quality of life and choices, education in the Solow-Swan model uses it as a mean to calculate output, or GDP. This further provides an issue for the HIHD model by having education and GDP correlate with one another.

It is also expected that education, in both models, can correlate with ideas in the Solow-Swan model since ideas stem from human resources.

[4] In his article *Handlekraft, Kjøpekraft og Velferd – Norges økonomiske vekst under Norges Banks Pengeregime*. In Aslaksen, K. O. & Amoriza, S. E. (eds), *Byrde og Berikelse: Sølvskatten 1816-2016*, Bergen, p. 8-23, 2016

The Neo-classical growth model is used to explain economic growth. The Solow-Swan model is a popular version of it (Corporate Finance Institute, 2015). This model combines the following production factors: labour, capital and technology. Technology being the way we combine these factors in more efficient ways. Which we can see below:

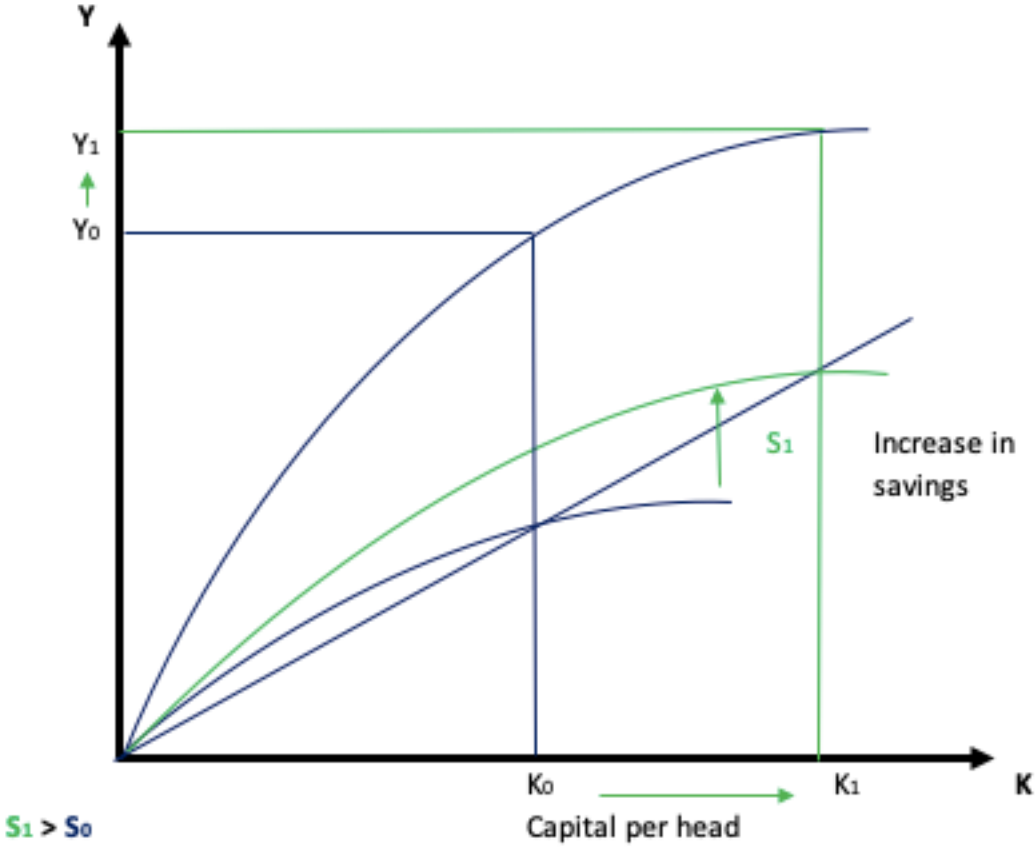
$$Y = A * f(K, eL) \tag{1}$$

Y = Output (GDP)
A = Ideas
K = Capital
e = Education
L = Labour

The theory claims that short term economic equilibrium is the result of varying amounts, and an efficient composition of labour and capital. Education also plays an increasing role for the efficiency of the labour force. The underlying thought is that the more educated people are, the more efficient they become. The growth reaches a state of steady level where capital depreciations equals investments. Ideas may improve the combination of capital and labour, creating more output for the economy, using the same amount of input (Corporate Finance Institute, 2015). This is a way where an economy can keep on growing without increasing their savings rate.

These relationships are illustrated in figure 2.3 and 2.4:

Figure 2.3: Neo-classical growth model, increased output due to increased savings rate (increased S).

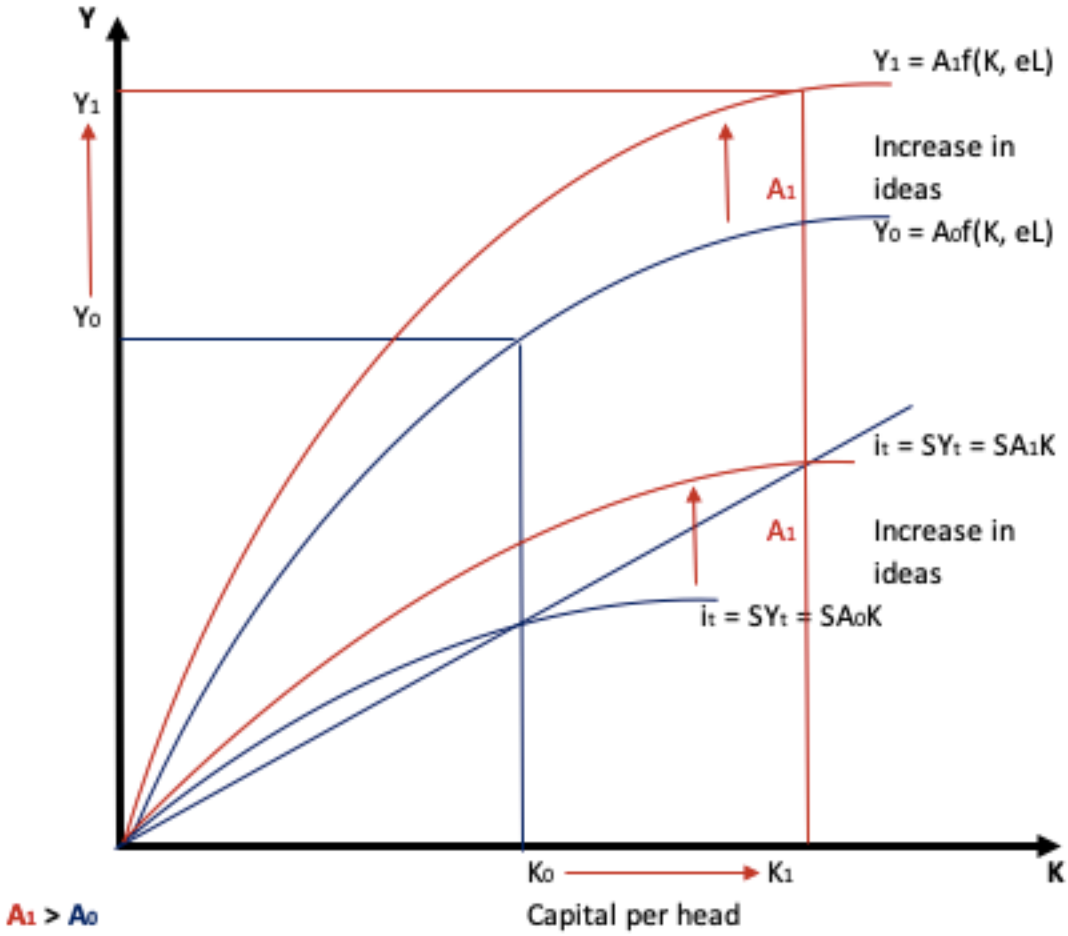


(Corporate Finance Institute, 2015)

The model builds on the assumption that a certain population save a constant proportion, s, of their income and consume the rest. In a later period, the savings are turned into investments (I). The first graph illustrates that an increase in savings can increase the investments which further increase output in the long run.

$$S_0 \rightarrow S_1 \text{ \& } S_1 > S_0 \Rightarrow I_0 \rightarrow I_1 \Rightarrow K_0 \rightarrow K_1 \Rightarrow Y_0 \rightarrow Y_1 \text{ (Increase in output)} \quad (2)$$

Figure 2.4: Neo-classical growth model with increased output due to better ideas (increase in A).



(Corporate Finance Institute, 2015)

From the figure, one can see that by increasing A, improving or generating new ideas, the composition of labour (L), education (e) and capital (K) can become more efficient. Society needs local infrastructure materialised as policies, education and laws in place to create incentives for ideas to be created.

$A_0 \rightarrow A_1 \Rightarrow eL*K$ (efficiency increased) $\Rightarrow K_0 \rightarrow K_1 \Rightarrow Y_0 \rightarrow Y_1$ (Increased output) (3)

Capital in the neo classical growth model does not fully reflect the HDI or HIHD models. Simply because these models do not directly address capital. However, the model should implicitly suggest a clear positive relationship between economic growth and human development.

2.5 The Human Development Index Model

We have previously defined what the HDI is and will in this section divide it into its components.

2.5.1 Gross National Income

The first dimension is the Gross National Income per capita (GNI). GNI reflects the total domestic and foreign output created by the residents within a country (Corporate Finance Institute, 2020). This measures a decent standard of living and should be adjusted for the price level of each country. This measure is included because economic growth has allowed certain parts of the world to break free from poor health, hunger and limited access to formal education (Roser, 2014). Since there is a diminishing return of income with increasing GNI, HDI uses the logarithm of income to reflect this (UN, 2019).

2.5.2 Life expectancy

The second component of the HDI is life expectancy. This addresses people's access to a long and healthy life and is measured by life expectancy at birth (Roser, 2014). The United Nations estimates that the minimum life expectancy is 20 years and the maximum one is 85 years.

2.5.3 Education

The third component, which can be split into two separate components, is education. Roser points out that education has been one of the main drivers behind global development. Hence, it is viewed as a basic right, with pressure being put on governments to provide quality education for everyone (2014).

Expected years of schooling

The first educational component is expected years of schooling. The United Nations' average maximum expected years of schooling is 18 years (Roser, 2014).

Mean years of schooling

The second component is mean years of schooling. This component measures the mean years of schooling for the adult population. Hence, the average years of schooling an adult at 25 years or above have received. Here, the UN's mean maximum years of schooling is 15 (Roser, 2014).

We have now explained the three dimensions that are included in this model. This is depicted in the figure 2.5:

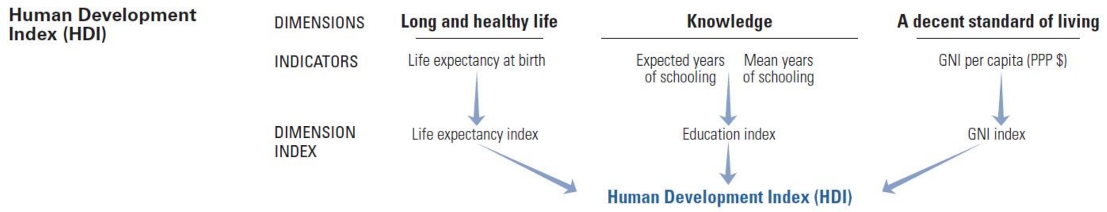


Figure 2.5: illustrates the different factors needed to construct HDI (Human Development Report, 2019).

2.6 Model: Historical Index of Human Development

The HIDI is constructed on the basis of somewhat different datasets. This is due to limitations by historical data availability.

2.6.1 Gross Domestic Product

The Historical Index of Human Development (HIHD) utilise gross domestic product per capita (GDP) to assess the standard of living (Roser, 2014). GDP per capita has no upper bound in these calculations. Therefore, GDP per capita will use the index formula of HDI where we log M, M_0 and x. This way the returns of per capita income will decline as it reaches higher levels.

It is important that the GDP per capita is adjusted for purchasing power parity (PPP), which means that the GDP is adjusted for different price level and different currency rates, for a specific year in order to make the numbers comparable over time, borders and currencies.

GDP reflects the sum of gross value added in all production units of the economy. This can be calculated through the production approach, the expenditure approach and the income approach. The **production approach** sums up the gross value added (y), in all production units (j), by subtracting the gross value of intermediate consumption (h) from gross value of output (g) in period (t). This is mathematically illustrated in equation 4 (Grytten, 2020):

$$\sum y_{j,t} = \sum(q_{j,t} - h_{j,t}) \tag{4}$$

y = Gross Product (value added)
j = Production units
h = Value of intermediate consumption
q = Gross value of output
t = Time period

By adding the sums of all production units one can find the economy wide aggregates:

$$Y_t^B = Q_t - H_t \tag{5}$$

Y^B = GDP in base values (prices)

By using this method, one reaches GDP in base values (prices) (Y^B). GDP in market values (prices) (Y^M) are reached by adding net product taxes, calculated as gross product taxes (T^Q), subtracted by product subsidies (S^Q). This is illustrated below (Grytten, 2020):

$$Y_t^M = Q_t - H_t + (T_t^Q - S_t^Q) \tag{6}$$

Y^M = GDP in market values (prices)
T^Q = Gross product taxes
S^Q = Product subsidies
(T^Q - S^Q) = Net product taxes
Q_t = Gross Values of Output (economy wide aggregate)
H_t = Gross values of intermediate consumption (economy wide aggregate)

While GDP (Y) from production approach describes supply, the GDP calculated by the **expenditure approach** describes use or the demand side of the aggregated economy:

$$Y_t = C_t + I_t + G_t + (X_t - M_t) \quad (7)$$

Y_t = GDP from the production side

C_t = Private consumption

I_t = Gross investments

G_t = Public expenditures

X_t = Exports

M_t = Imports

$(X_t – M_t)$ = Net exports

The **income approach** describes the income distribution of the GDP following way:

$$Y_t = W_t + S_t + (T_t^Q - S_t^Q) + (T_t^M - S_t^M) \quad (8)$$

W = Compensation of empoyees (wages)

S = Gross operating surplus

T = Taxes

S = Subsidies

Q = Production

M = Imports

T = Time period

Further explanations on how to calculate and adjust for price indices and Purchasing Power Parities (PPPs) are placed in the appendix.

2.6.2 Life Expectancy

Life expectancy at birth is the measurement for this dimension. The United Nations defines it as "*the average number of years of life which would remain for males and females reaching the ages specified if they continue to be subject to the same mortality experienced in the year(s) to which these life expectancies refer*" (United Nations, 2000; Escosura, 2014). This would imply that if a minimum and maximum of e.g., 20 and 85, respectively, would be utilised, life expectancy would use these goalposts for all the time periods, while the age would be adjusted to fit within these. Escosura (2015) applies these goalposts (2015). Therefore, we will use them too.

2.6.3 Education

To measure the level of education of a population the education index is split into a school enrolment rate and an adult literacy rate.

School enrolment

The school enrolment rate captures the expansion of the formal education without informing about the length of the academic year, quality of education or student completion. This provides the percentage of the population in relevant ages enrolled in primary, secondary and tertiary education (Escosura, 2019). Historical evidence allows one to estimate the unadjusted rate of total enrolment, i.e., the percentage of the population aged between 5-24 enrolled in primary, secondary and tertiary education (Escosura, 2015).

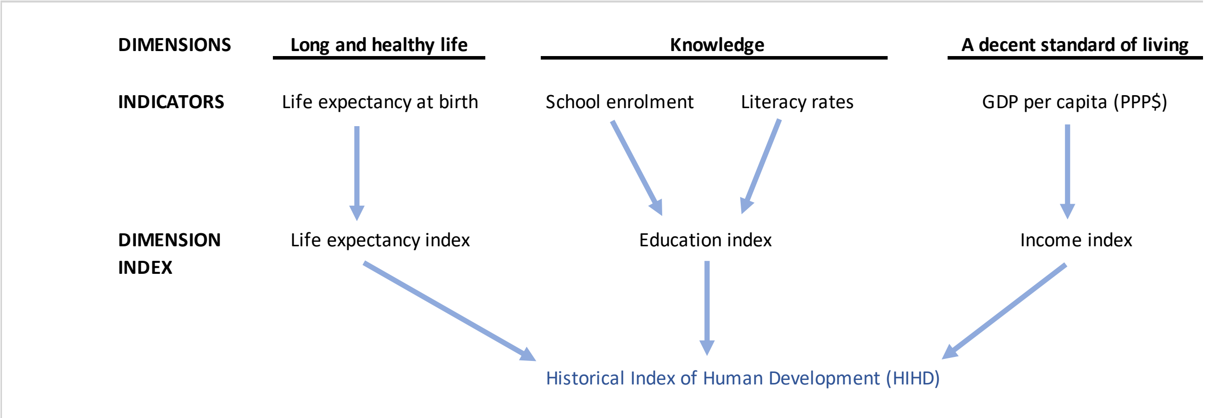
Adult literacy

The rate of adult literacy is defined by the population aged 15 years or above who can both read and write (Escosura, 2014). Unfortunately, adult literacy seems to not be a universal concept, and reading and writing skills are measured differently between time periods and countries.

Both the education indicators use goalposts ($M = 100$ & $M_0 = 0$) which were used by Escosura, and will be used here, despite the highest and lowest historical values being set at 99 and 0 (Escosura, 2015).

All these four indicators are used to construct the same four dimensions as in the HDI. We insert these into figure 2.5 replacing them with its previous indicators. This gives us a model for the HIHD which we demonstrate in figure 2.6:

Figure 2.6: An illustration of the factors needed to construct the HIHD.



In the following we will use this theory on HIHD extensively in our study. To a significant extent its theoretical foundation rests on the classical growth model, here we apply the Solow-Swan model.

3. Method

3.1 How to calculate HDI

We will in this section follow Roser (2014) on how to calculate HDI. There are two steps. The first being forming indices for each of the four metrics. And the second being aggregating the four metrics to produce the HDI.

3.1.1 Step 1: Forming indices for the metrics

The dimensions are made computable by measuring them as metrics. These will be normalised into indices of value 0 to 1. UNDP set maximum and minimum, "goalposts", limits to each metric. This is demonstrated in table 3.1.

Table 3.1: Goalposts for metrics in the HDI.

Dimension	Indicator	Minimum	Maximum
Health	Life expectancy (years)	20	85
Education	Expected years of schooling (years)	0	18
	Mean years of schooling (years)	0	15
Standard of living	GNI per capita (2011 PPP $)	$100	$75000

(Roser, 2014).

Having the actual value for a given country one can, in combination with the goalposts, calculate the indices of each metric the following way:

$$Dimension\ Index\ = \frac{Actual\ Value - Minimum\ Value}{Maximum\ Value - Minimum\ Value} \tag{9}$$

Simplified we can express this as:

$$I\ = \frac{x - M_0}{M - M_0} \tag{10}$$

A country that scores 1 in the dimension index has achieved maximum value, while a country that has achieved the minimum value scores 0 (Roser, 2014).

3.1.2 Step 2: Aggregating the metrics into HDI

The second step focuses on aggregating the four calculated sub-indices. This gives the HDI. It is calculated as the geometric mean (equally weighted) of the dimensions (Roser, 2014):

$$HDI = (I_{Health} * I_{Education} * I_{Income})^{1/3} \quad (11)$$

Where the education index is calculated by finding the geometric mean (equally weighted) of the expected years of schooling index and the mean years of schooling index:

$$I_{Education} = (I_{Expected\ schooling} * I_{Mean\ schooling})^{1/2} \quad (12)$$

3.2 How to Calculate HIHD

To calculate the HIHD we will use the same two steps. However, the calculations within the steps are not identical to those of the HDI.

3.2.1 Step 1: Forming indices for metrics

The method in which the metrics are converted into indices between 1 and 0 differ between the HIHD and the HDI. While the HDI scales the metrics linearly, using their actual values, bounded in maximum and minimum values, the HIHD scales them non-linearly (Roser, 2014). Escosura, (2014) further notes that:

"As ***social variables*** *(longetivity (life expectancy) and education) have upper and lower bounds (unlike GDP per head that has not known upper bound), they are transformed nonlinearly in order to allow for two main facts: that increases of the same absolute size represents greater achievements the higher the level at which they take place; and that quality improvements are associated to increases in quantity."*

Hence, the variables are scaled logarithmically and the indices for the social variables; education and longevity are calculated the following way:

$$I = \frac{log(M-M_0) - log(M-x)}{log(M-M_0)} \quad (13)$$

I = Dimension index

X = Indicator of a country's standard of living

M = Maximum values (goalpost which facilitate comparisons over time)

M_0 = Minimum values (goalpost which facilitate comparisons over time)

Log = Natural logarithm

Each dimension's index is defined in the interval between 0 and 1 (Roser, 2014).

However, GDP per capita will use the index formula of the HDI where we log M, M_0 and x because they naturally have no upper or lower bounds. This way the returns of per capita income will decline as it reaches higher levels. Hence, the income index will look different from that of the two social variables:

$$I_{Income} = \frac{log\ (x) - log\ (M_0)}{log\ (M) - log\ (M_0)} \tag{14}$$

3.2.2 Step 2: Aggregating metrics to calculate HDI

Then, the four indices are combined to calculate the HIHD using a geometric average (Roser, 2014; Escosura, 2015):

$$HIHD = (I_{Health} * I_{Education} * I_{Income})^{1/3} \tag{15}$$

Where the education index is the geometric mean (equally weighted) of the school enrolment index and the literacy rate index:

$$I_{Education} = (I_{School\ enrolement} * \ I_{Literacy\ rate})^{1/2} \tag{16}$$

The following benchmark years will be utilised, as shown in table 3.2.

Table 3.2: Goalposts for metrics in the HIHD.

Dimension	Indicator	Minimum	Maximum
Health	Life expectancy (years)	25	85
Education	School enrolment	0	100
	Literacy rate	0	100
Standard of living	GDP per capita (1990 PPP $)	$100	$46 949

(Escosura, 2015).

4. Data and construction of indicators

4.1 Introduction

This chapter aims at describing and evaluating the data behind our new HIHD series and its components. The new series are also presented here. These make up the foundations for the calculations of new HIHD series for Denmark, Norway and Sweden from 1820 to 2019.
We present the data and related sources for each dimension. Further, we present the data as time series. This way we can see the development of the data, which provides us with an overview of each dimension in each country and how they compare to one another.

4.2 Critical View of Existing Data

In this section we will explain why we believe the data of the existing HIHD could be improved for a more accurate time series.

Escosura use the Geary-Khamis dollar as of 1990 (G-K $1990) in his fixed price series. This is a hypothetical currency equal in value to the United States dollar at a standard point in time. It is often used to demonstrate topics such as purchasing power parities (PPPs) (Farlex Financial Dictionary, 2012). The G-K $1990 are hardly optimal of two reasons. In the first place they reflect purchasing power parities (PPPs) of raw as they were in 1990. Because of very low raw material prices this year, raw material based economies do not perform well according to these calculations. Secondly, the Maddison GDP figures stretching back in time from the 1990 PPPs have been heavily criticised over dubious assumptions. E.g., he assumed that Norway had a GDP per capita 10 percent under Sweden in 1820 and interpolated the GDP series closer to our time on the basis of this assumption, which is quite dubious (Grytten, 2004; Grytten, 2020). US$ of 2005 fixed price calculations in PPP demonstrate a more realistic picture of the relative wealth between Denmark, Norway and Sweden.

By the look of Escosura's time series of the education index, they seem to have limited empirical rooting compared to the other components in his dataset. By following the empirical sources, the data he builds his research on are not complete. Therefore, his calculations lack sufficient empirical grounding. However, given his grand work with so many nations it is quite impressive. However, when looking at the details one can see that the numbers for the Nordic countries do not rest on sufficiently rich data material.

Peter Flora published in 1973 his book *Historical Process of Social Mobilization: Urbanization and* Literacy*, 1850-1965*[5], where he presented the illiteracy rate of several countries. Among these; Norway, Sweden and Denmark. He defines illiteracy as those with neither the ability to read nor write (Flora, 1973). Escosura mainly bases his calculations of literacy rates on these illiteracy rates adjusted with rates from the research of researchers like Markussen (1985) and Johansson (1977) as well as using interpolations.

Escosura, however, theoretically defines his literacy rates to include people with the ability to both read and write (2015). Hence, the two definitions do not reflect one another. Flora's numbers can, therefore, include those who possess only one of the abilities. This is in turn most likely transferred over to Esocosura's rates of literacy, making his rates of literacy higher for the 1800s then what they should have been. This likely makes his literacy series and education index higher than what would have been the case.

In the section on education, one needs to compute numbers that better reflect the reality of literacy and education back in the 1800s by taking a deeper dive into the established literature in the field.

Therefore, we will gather new data for our three dimensions; income, health and education. For education we collect data for its two sub-dimensions; school enrolment and literacy rates.

4.3 Gross Domestic Product per capita

GDP per capita utilised for the calculations in this thesis are all calculated in GDP per capita in purchasing power parities in G-K 1990 dollars. These are adjusted for the relative differences of the GDP per capita in purchasing power parities in 2005 US dollars. The data for the 2005 US dollars are retrieved from Grytten (2020), Edvinsson (2013), and Hansen (1983), while the data for the G-K 1990 dollars are retrieved from Maddison (2010).

4.3.1 Norway

In the article *"Two Centuries of Economic Growth: Norwegian GDP 1816-2020"* Grytten (2020) offers new estimates of Norwegian gross domestic product from the production and

[5] In S. N. Eisenstadt and S. Rokkan (eds), *Building States and Nations: Models and Data Resources*, Sage, London 2013-50, 1973

expenditure side from 1816 to 2019. These calculations are done on the basis of available sources on input, output volumes and prices. The series are more in line with international trends and business cycles than the previous ones (Grytten, 2020).

4.3.2 Sweden

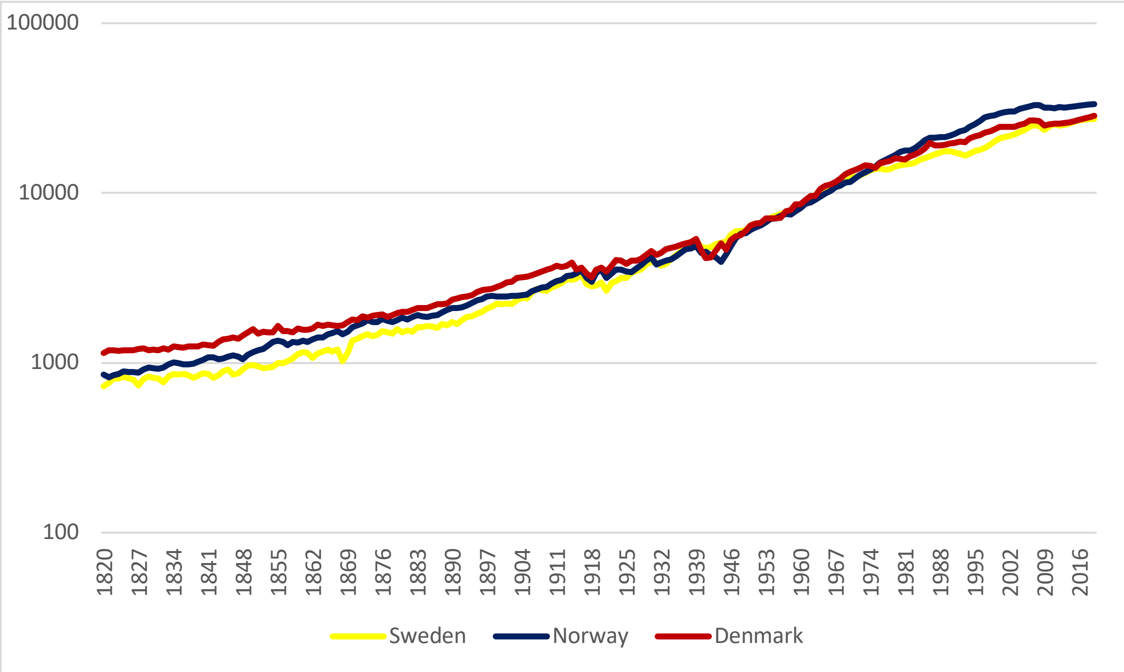
The data for the Swedish GDP per capita is taken from Edvinsson (2013) *"New annual estimates of Swedish GDP, 1800-2010"*. The numbers are updated and calculated up until 2019 by Grytten (2020), using the same method as Edvinsson.

4.3.3 Denmark

As for the GDP per capita numbers from Denmark, we use Hansen (1983): *Økonomisk vækst i Danmark 1914*-1983 and *Økonomisk vækst i Danmark 1720-1914*. The numbers are updated to 2019 by Grytten (2020) using the same method of calculation. They are also adjusted to US$ 2005 in PPPs. Figure 4.1. depicts GDP per capita for our three selected countries.

It seems difficult to locate full valid datasets for GDP per capita adjusted for Purchasing Power Parities in US$2005. Hence, we have decided to apply PPP G-K$ 1990 and adjust them to maintain the relative differences of the PPP in US $2005. These better reflects the relative difference between the Scandinavian countries, rather than those of the Maddison database. Also, by linking them to the G-K$ 1990 level we have numbers that we can compare to existing research. This way, we maintain the relative differences of the US$ 2005 in $1990. The results are shown in figure 4.1.

Figure 4.1: GDP per capita in adjusted G-K$ 1990 PPP for Denmark, Norway and Sweden from 1820 to 2019 (semi-logarithmic scale).



(Grytten, 2020; Edvinsson, 2013; Hansen, 1983; Maddison, 2010).

The Maddison database also provides time series with the US$ 2011 PPP which are more up to date. However, in 2011 the Norwegian oil prices were at a very high level reaching an annual average of $111 per barrel (E24, 2011). Since oil prices do affect the Norwegian GDP numbers based on this year's price level, it will be significantly higher than what normally would be the case. Thus, we dismiss them for our use.

4.3.4 Validity of GDP per capita

The US$ 2005 fixed price GDP per capita figures would reflect relevant and valid numbers for this analysis. For our measures we adjusted the G-K $1990 to the relative differences of the US$ 2005, which make them more valid and relevant for our study. We believe these numbers to be better suited since they better reflect the normal relative differences of the Scandinavian GDP per capita. This way the numbers will be a relevant and valid approximation of the relative wealth between Denmark, Norway and Sweden. Thus, they will be valid to use for comparisons between them.

4.3.5 Reliability of GDP per capita

The initial G-K$ 1990 are retrieved from the Maddison (2010) database set while the US$ 2005 are calculated by Grytten (2020) for Norway, Edvinsson (2013) for Sweden and Hansen (1983) for Denmark. Hence, based on these sources the numbers seem to be reliable to use for further research. The time series in themselves build on very detailed data sets. Additionally, the Norwegian and Swedish series are to a large extent calculated by a double deflation technique, which make the fixed price calculations uniquely reliable in comparison with historical GDP series for most other countries.

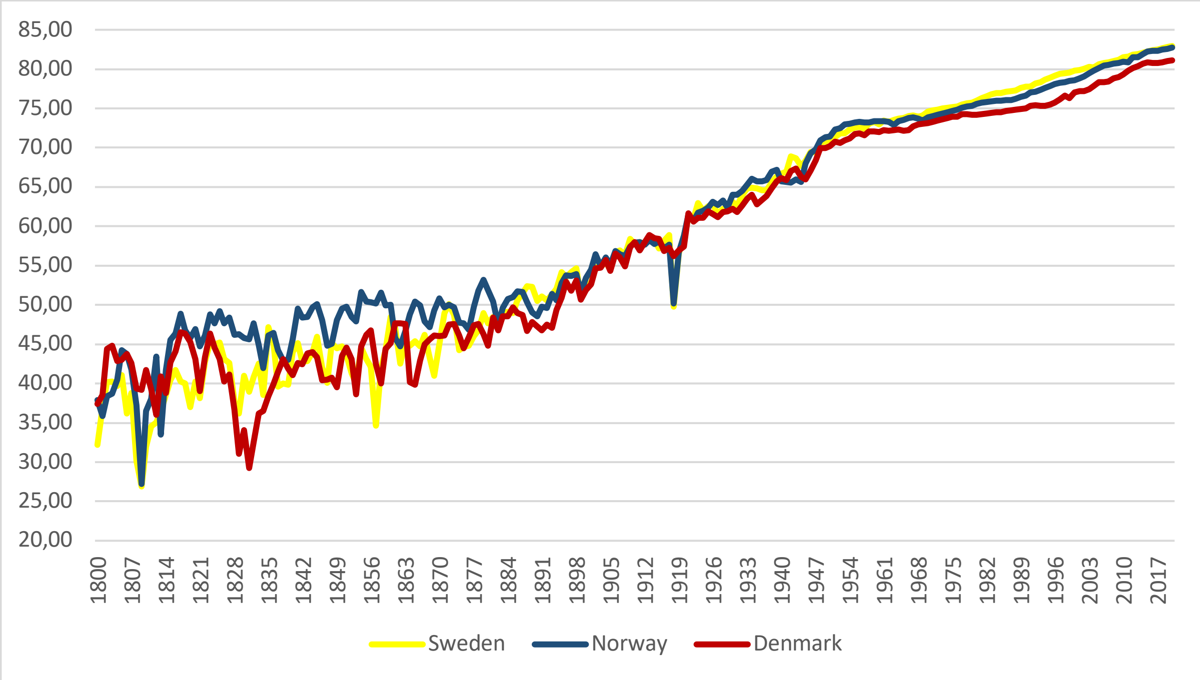
4.4 Life expectancy

For life expectancy all the numbers have been retrieved from Gapminder, which again have compiled their numbers from the national statistical offices, Lindgren (2008), and the Institute for Health Metrics and Evaluation (IHME), University of Washington, Seattle. The United Nations (UN) is the main source for the three latter years, 2017-2020 (Gapminder, 2020).

These numbers are close to identical to those of Escosura. However, they go further back in time for Norway and Denmark, and they are made on the basis of actual registrations by church offices and public statistical offices (Norges Offisielle Statistikk, 1994).

Figure 4.2 reports a constructed graph for the life expectancy for Denmark, Norway and Sweden for 1800-2020.

Figure 4.2: Life expectancy at birth for Denmark, Norway and Sweden, 1800-2020



(Gapminder, 2020).

At the early 1800s life expectancy was unstable for all three countries. However, Norway established a leading role in life expectancy until the 1880s. Thereafter, life expectancies converged. Towards 2020 there were minor differences between the three countries.

4.4.1 Validity of Life Expectancy

In terms of validity the life expectancy does in fact measure what it is supposed to measure, the expected life span of the average individual. Therefore, we can use this dimension to measure development in longevity. Their validity seems as best practise for historical data. However, they do reflect more average lifetime than life expectancy, as the latter is measured by the former. However, this applies also for modern HDIs series of life expectancy.

4.4.2 Reliability of Life Expectancy

The numbers are taken from a somewhat unorthodox source, Gapminder. However, these are again taken from public registrations at the time and assessed by public servants and the Statistical offices of the three Scandinavian countries. After having compared the life expectancies of Gapminder with those of Escosura, those of Our World In Data from Roser (2014) and those of the public records from the three Scandinavian countries, the numbers seem to be almost identical and reliable (Mitchell, 1998).

4.5 School enrolment

For school enrolment from age group 5-24 for the years 1820-1900 we have used data from the national statistical offices and *International Historical Statistics: Europe 1750-1993* (Mitchell, 1998). For 1913-2015 we have used the enrolment rates of Escosura (2015).

4.5.1 Norway

Statistics Norway (1994) reports data on enrolment from the 19th century, where numbers of students are registered randomly for primary, secondary and tertiary education These series start in 1840/1841 and continue with random intervals until 1900/1901.

To calculate enrolment for primary education we utilise numbers of students in benchmark years 1840/1841, 1853/1854, 1870/1871, 1880/1881, 1890/1891 and 1900/1901.

From 1739 schooling was compulsory in Denmark-Norway. However, in the countryside, it was often confined to a few weeks a year, while it was held more frequently in the cities (Dokka, 1988). Still 90 percent of the population lived at the countryside in 1800.

A new school law in 1847 demanded at least two months of education each year for seven years. Further, a new law in 1848 enforced education in the cities to be at least 18-24 hours a week for 4-5 months a year. In 1860 it became compulsory to have a fixed school program everywhere, increasing the hours of education even further.

To be able to arrive at enrolment rates, it is imperative to take the number of school days into account. We calculate the number of school days into months according to the requirements of the laws. Also, we assume that schooling increased gradually in-between the implementations of the new laws, since they often reflected the local reality. This way we can calculate adjustment factors for the numbers of students enrolled, according to their efficient time of education. We calculate annual figures by assuming a log-linear development between the benchmark years, and, therefore, reflect compound growth rates.

Statistics Norway (1994) also reports numbers of students in secondary education, gymnasiums, continuation schools and folk high schools. They start in 1875/1876 and continue around every fifth year until 1900/1901. There are also private records from 1864. All these students were full time students and should account accordingly.

For tertiary education Statistics Norway reports the number of students enrolled at the University of Oslo from 1813, thereafter for every decade from 1820 onwards. Unfortunately, we do not have good data on students at teachers training programs and agricultural colleges. However, the number of teachers, and, thus, candidates who went through teachers training are reflected in the student enrolment. Thus, we incorporate these in our estimates.

After arriving at different benchmark-years one has to interpolate between these to reach annual enrolment figures. To do so we need enrolment as share of the age interval 5-24 years. The number within the age group is found in the population censuses every tenth year until 1900. We interpolate log-linearly between these, to reach annual series.

4.5.2 Denmark

Like Norway, Denmark started confirmation in 1736 and followed up with compulsory education in 1739.

Mitchell's work only provides us with data for Danish primary education in 1893, 1897 and 1902. Thus, we use these three benchmark years to calculate annual primary enrolment for Denmark 1893-1902 by applying compound growth rates between the observations. For the years 1820-1892 we use relative enrolment rates similar to the Norwegian ones.

To establish numbers for secondary education we find the data by Mitchell are too low since his data accounts for gymnasiums only (Mitchell, 1998). Hence, we multiply our benchmark years for 1893, 1897 and 1902 by a factor reflecting this under-reporting to arrive at comparable enrolment numbers over time and cross border to Norway and Sweden. Further, we estimate numbers back to 1852 by extrapolations based on the Norwegian development.

For university enrolment Mitchell presents numbers for the years 1893-1900. However, these seem far too low since they are lower than both those for Sweden and Norway, despite that Denmark had 10 teacher training colleges early on. We extrapolate numbers from 1893 back to 1820 assuming the same development as for Norway. Thereafter, we calculate people enrolled in other forms of education by using the empirical ratios to Norway.

Finally, we add primary, secondary, university and other education together. Thereafter, we find the percentages from the population aged 5-24 years. To arrive at a time series for 1820-2015 we then combine our estimates 1820-1913 with Escosura's data from 1913-2015.

4.4.3 Sweden

Sweden's first literacy, and thus, education campaign began in 1686 through the Church Law which stated that all should be able to see God's bidding with their own eyes (Johansson, 1977). From this a system emerged relying on home schooling and annual in-home testing conducted by the local priest.

Furthermore, Sweden started its compulsory schooling in 1842 through the Elementary Education Code. However, before this half the parishes already had a school. These schools were mainly in the south and came about through Danish influence on the region.

To acquire enrolment rates for Sweden during this time period we first retrieved data about primary, secondary and university education from Mitchell's book; *International Historical Statistics: Europe 1750-1993* (Mitchell, 1998). Based on these numbers we have, by calculations, estimated enrolment rates from 1820-1900. Further, we combine these numbers by adding them to the rates of Escosura (2015) from 1913 to 2015. The years in-between, 1901-1912, are found by calculating the compound growth rate between 1900 and 1913.

Mitchell's numbers for primary education stretches back to 1865. In the time period 1865-1900 we have 1865, 1868, 1870, 1875, 1886, 1890, 1898, 1899 and 1900 as benchmark years. The lacking years are found as a log-linear growth trend. However, we lack benchmark values for the time period 1820-1865. Thus, we conclude that Sweden had the same relative enrolment as Norway for the time period subtracting 25% due to their later adaptation of compulsory public schooling.

For secondary education Mitchell reports data back to 1888. We use the rates from 1888-1900 spliced with modern series. For the time span 1820-1887 we prolonged the series by using the empirical ratio to the Danish numbers as of 1888.

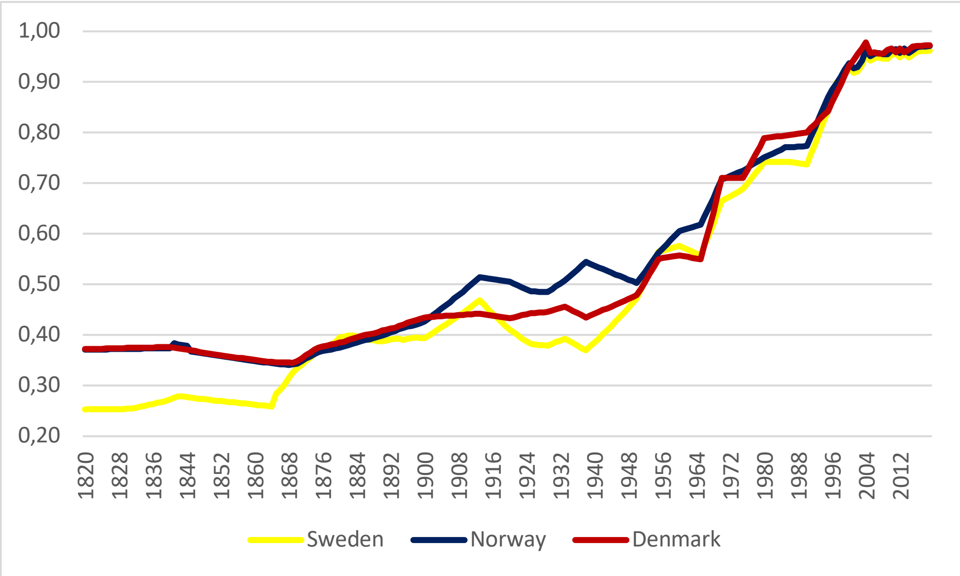
Mitchell's university numbers for Sweden stretch back to 1910. However, they go further back for Denmark. Hence, we use the ratio of Swedish university students to the Danish for every year in the period 1820-1900. Thereafter, we calculated people enrolled in other forms of education by using the relative number for Norway as of 1910.

Further, we add the primary, secondary, university and other education together. We then calculate them as percentages of the population 5-24 years, compiled from national demographic data.

When arriving at a time series from 1820-1900 we connect them to Escosura's numbers (2015) 1913-2015. We compute estimates for the years 1901-1912 by calculating compound growth rates for the years between the two data sets.

However, the numbers from the end of the 1990s and 2000s of Escosura are unstable. Hence, we found it reasonable to adjust these numbers by data from the national statistical offices. For the years 2015-2020 we have assumed that all three countries converged to 99%. Having arrived at enrolment rates for Norway, Sweden and Denmark for the following years we can see the development as depicted in figure 4.3.

Figure 4.3: Enrolment rates (5-24 years) for Denmark, Norway and Sweden 1820-2020



(Escosura, 2015; Mitchell, 1998).

In this figure we can see that Norway and Denmark follow each other closely most of the time, above Sweden. After World War II they all seem to have a similar development.

4.5.4 Validity of Enrolment rates

These data capture the enrolment within primary, secondary and tertiary (university) education. From 1900 they are mostly retrieved from Mitchell's (1998) for Denmark and Sweden. However, many of their numbers are also retrieved from the relative numbers of Norway which we compiled from Statistics Norway. Thereafter, we merged them with the numbers of Escosura from 1913. These numbers are applied in existing research. We find that his revised data and the new data we calculated to be similar. This is because they are linked to modern series and spliced with them in overlapping years. Also, we find these records to be more persistent over time, with less structural breaks. Further, we estimated some new numbers for the last 20 years on the basis of present data. Hence, the time series should be valid to represent the Scandinavian school enrolment for our purpose.

4.5.5 Reliability of Enrolment rates

It is worth mentioning that we use log-linear interpolations between our benchmark rates. Also, the development of the Mitchell numbers and Statistics Norway numbers seem to splice well with those of Escosura, making the development seem reliable. In addition, the numbers seem to follow the literature on the topic, with Denmark taking the lead and Norway being second, followed by Sweden. In conclusion, we believe they reflect the historical development. This make the enrolment rates reliable for usage.

4.6 Literacy rates

Tveit (1991) claims that literacy first came to Sweden, then to Denmark, and finally Norway. Later, Denmark surpassed Sweden during the 18th century. However, this definition of literacy seems to cover reading only. Flora's illiteracy numbers, which is a broader definition of literacy than the common one, requires the ability to both read and write.

Literacy in the Scandinavian countries is historically divided into two categories:

a. The ability to read
b. The ability to write

Writing was often related to occupational diversification and specialisation. It was considered a challenge to the ruling elite. Hence, the ability to write developed at a slower pace than reading. Denmark first made writing compulsory in school education in 1814, Norway and Sweden followed in the 1820s and 1840s respectively (Tveit, 1991).

4.6.1 Norway

A full statistical set of literacy rates for 1820-1900 is unavailable. It seems, however, to be a consensus that almost every Norwegian was able to read, to various degrees, during this period (Byberg, 2008). Malthus (1799), claimed as early as 1799 that a majority of Norwegians could read quite well. This was a result of compulsory confirmation from 1736 and compulsory public school from 1739, which was introduced in Denmark-Norway to enable the population to read the Bible and the Lutheran catechism (Tveit, 1991).

However, only a minority of the students learnt how to write. Early on local and regional school authorities introduced writing in clusters in Norwegian compulsory schooling. The Christian Sunday school was another pioneer of teaching writing skills. This was influenced by the pietist movement in the 18th century and the puritan Haugean movement of the 19th century (Haukeland, 2014). Malthus (1799) claimed that a significant bulk of Norwegians that could read, also were able to write. However, he does not mention any explicit numbers. In the 1850s classes in writing were only attended by a minority of students, and it did not have its full breakthrough in Norway before the School Act of 1860. This act brought permanently established schools throughout Norway in a few years (Tveit, 1991).

The ideal series of literacy rates through the 19th century does not exist because very little has been done to quantify these rates. However, Vannebo (1984) tried to measure comparable literacy rates in form of writing skills for 1837, 1840, 1853 and 1885. The years are chosen on the basis of county reports on reading skills among schoolers.

After having extensively examined available data, Vannebo concludes there being literacy rates of 26.8%, 30% and 47.1% in 1837, 1840 and 1853 respectively, and close to 100% in 1885. These are presented in three groups; “those who can replicate a text properly”, “those who can replicate a text satisfactory” and “those who can copy using the text in front of them”. To meet the strict definitions of the HIHD one should count the first two groups only.

This leaves us with the rate of the adult population with proper writing skills in 1885 of 81.5%. Further, Vannebo assumes that the distribution of writing skills applies for the years ahead, i.e., 44.8% of those with writing skills belong to the high skilled group while 36.7% to the moderate skilled group. 18.5% to the non-satisfactory group. Whether this is correct, however, is not obvious. From 1837, 1840 and 1853 the survey only reports those who learned how to write at schools as individuals. Thus, we can assume that those only able to replicate a written text in front of them, were not included as having writing skills. Hence, it seems correct to assume all writing skills as satisfactory for these years.

Towards 1885, Vannebo (1984) assumes that the number of people with a sufficient ability to read probably is underestimated. This becomes clear once we compare the development with Denmark and Sweden. At the same time Tveit (1991) assumes that the writing skills were slightly better in Sweden towards 1889. Therefore, we conclude it is reasonable to assume that the Norwegian literacy rate in 1885 would be 85.1%, as suggested by a deep dive into Vannebo's figures. We assume an annual growth rate of 1.25% between 1880 and 1885.

Fet (2003) claims that 60-70% of the Norwegian population could read properly in 1814. To a significant extent, this resulted from the Haugeans' emphasis on popular enlightenment, where both reading and writing were essential. If the number of writers corresponds with that of readers in 1837 one arrives at a writing rate of 18% in 1814.

Tveit (1991) concludes that 80% of the students were capable of writing in 1880 after percept. Fewer being able to freely write. For us to be able to reach annual writing skill rates for Norway, which also reflect literacy rates, since almost everyone could read, one has to interpolate between the benchmark years 1814, 1837, 1840, 1853, 1880 and 1885. We do this by applying an annualised log-linear model, reflecting compound growth rates between the benchmark years. Since teaching in writing had its breakthrough in 1860, we assume that growth rates diminishingly correspond to those for 1840-1853 continued until 1860. From then on, we find annual growth rates between the estimated 1860 and the 1880 rate.

4.6.2 Denmark

Like Norway and Sweden, Denmark also reached an early level of satisfactory general reading skills among its population after introducing compulsory confirmation in 1736 and compulsory education in 1739 (Tveit, 1991; Munck, 2004).

Denmark became the first Scandinavian country to reach full literacy. With its favourable geographical conditions for establishing permanent schools, Denmark, in 1814, became the first country to make writing a compulsory subject. Writing, orthography and reading of handwriting became required for admittance to confirmation in 1846. It has been suggested that by 1850 all Danish children received thorough instructions in writing and by 1860 an astonishing 88% of the population could read and write. As early as 1815 Denmark had ten teachers training colleges compared to none in the other Nordic countries (Tveit, 1991).

Reliable statistics is hard to come across. It is chiefly built on the ministry of defence's surveys on recruits' reading and writing abilities. They were conducted in 1859, where 88.3% knew how to read and write, and 1873, where 86.4% knew how to read and write (Markussen, 1985).

Having in mind that military recruits tend to be well educated, and among the top readers and writers, one may assume these benchmark values are too high. However, Denmark first established schooling, in 1814. Its geography made it easier to establish schools for the majority of the population. Hence, it is reasonable to assume Denmark was ahead of Sweden and Norway for the most of the 1800s. Markussen's estimate establishes Denmark at 88.3%, Norway, 54,6%, and Sweden, 52.2%, in 1859. Denmark showed marginal decrease towards 1873, when it reaches 86.4%, when Norway and Sweden reached 70.6% and 71.7% respectively. Since we need comparable data, we use 1873 as our benchmark year for Danish literacy rates. Then, we find the relative difference between Denmark and Norway for 1873. This shows that Denmark's literacy rate was 22.4% above that of Norway. Hence, we from 1872 and back to 1814 adjusted the Danish numbers to be of that proportion higher than the Norwegian ones.

To calculate the growth of Danish literacy after 1873 we found the rate to reach 99% in 1915. We then derive our growth rates for Denmark log-linearly between 1873 and 1915.

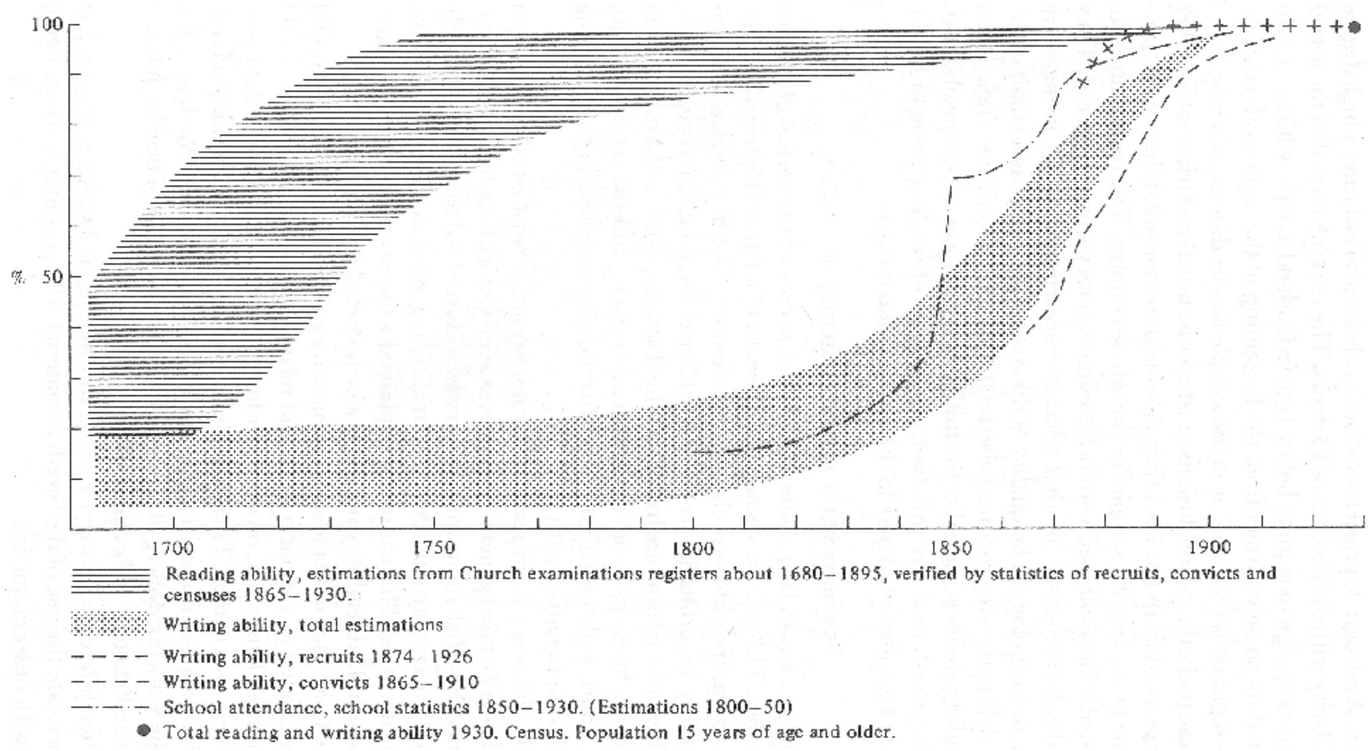
4.6.3 Sweden

Sweden started its first educational campaign achieving elementary literacy without a formal school system. The Church Law of 1686 contained rulings about general literacy. It further stated that children, farmhands, and maid servants should "*... learn to read and see with their own eyes what God bids and commands in His Holy Word*". Hence, reading was a mean to learn the meaning of the Bible and become, on an individual level, conscious of Christian faith (Johansson, 1977). Hence, one introduced a "husförhör" (household interview). Parish registers reported the results of the interviews in form of a survey constructed to map the religious knowledge in the parishes.

The survey was conducted by questioning residents in their own homes (Skovgaard-Petersen, 1990). Not passing these examinations implied that one could not fully participate in society, e.g., not getting married. Therefore, this created a huge incentive among the population to acquire the skill of reading. However, this was accomplished mainly through home instructions, since the number of schools was low at the time (Johansson, 1977; Tveit, 1991).

Around 1840 about half of the Swedish parishes had at least one school. However, the 1842 Elementary Education Code, motivated a transition from home schooling to public schooling. The transition was gradual and proved to be the turning point in the development of literacy (Tveit, 1991). The influx of students into the state schools made writing a general ability within the second half of the 19th century (Johansson, 1977). Figure 4.4 shows how Johansson illustrates his estimates.

Figure 4.4: Reading and writing traditions in Sweden 1680-1930.



(Johansson, 1977, figure 7).

To arrive at his estimations Johansson used official school statistics. More detailed aggregates reveal some development features, as he reports them in his work (Table 4.1).

Table 4.1: Deficient school teaching and deficient writing ability in Sweden 1850-1910. Comparison between children, recruits, convicts and the census of 1930. Percentage figures.

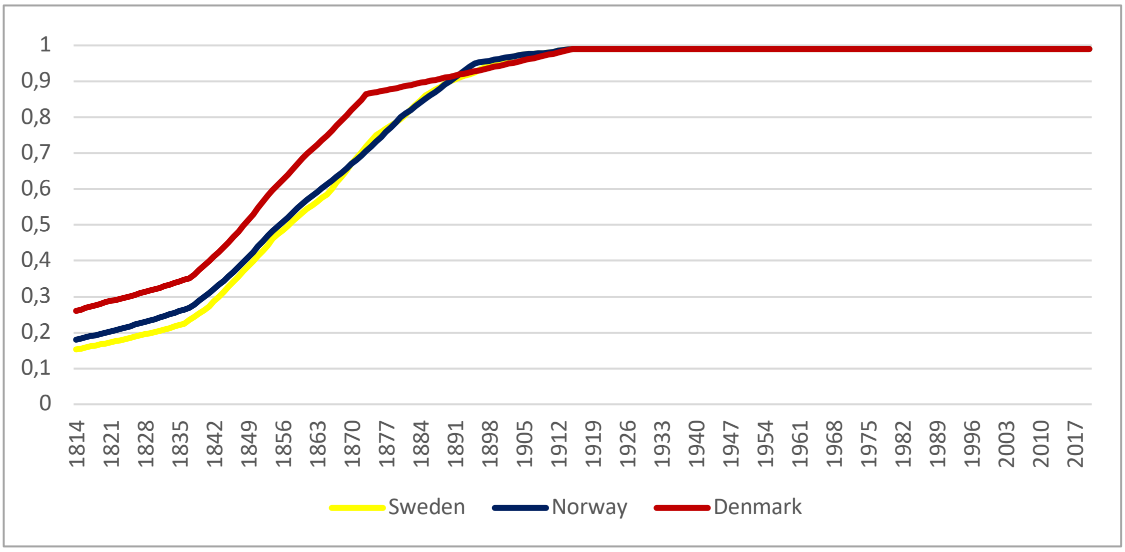
Year	Children Home instruction %	Recruits Not able to write %	Convicts Not able to write %	Census 1930 Not able to write %	Census 1930 No School teaching %
1850	30	-	-	-	-
1856	30	-	-	-	-
1859	27	-	-	-	-
1865	23	-	60	-	-
1870	13	-	53	-	-
1875	9	11	41	4	8
1880	7	5	34	-	-
1885	6	2	22	1	2
1890	4	1	16	-	-
1895	4	1	11	1	1
1900	2	1	6	-	-
1905	1	1	4	1	1
1910	1	0	4	-	-

(Johanssson, 1977, table 13)

The source demonstrates the percentage of children with home instructions, in addition to recruits and convicts that were not able to write satisfactory in the listed years. From this we can derive different rates of illiteracy. One may therefore derive literacy rates for each group based on these numbers. Recruits illustrates the lowest level of illiteracy followed by children with home instructions. Convicts seem to be at a significantly higher level. Literacy among the recruits would seem like a good indicator for the reading ability. Since we have a relatively high rate of literacy among children, and a relatively low one among convicts, we will construct a rate based on the arithmetic average of the groups.

Johansson estimates suggests that Sweden reached a state of full literacy, approximately 99% around 1900. Hence, we reach at the following benchmark years; 1865, 1870, 1875, 1880, 1885, 1890, 1895, 1900, 1905 and 1910. We use an annualised log-linear approach to find compound growth rates to interpolate between these benchmark years. This gives us the development of Scandinavian literacy rates as reported in figure 4.5.

Figure 4.5: Literacy rates for Denmark, Norway and Sweden 1814-2020.



(Johansson, 1977; Markussen, 1985; Vannebo, 1984)

4.6.4 Comparable Literacy rates

Since the present thesis rests on the work by Escosura, we need to use literacy rate series calculated on the basis of the same definitions as he applies. Thus, we have to use an extended understanding of the term. His rates stems from Flora (1973). They are significantly higher than the ones we have constructed. This can be explained by Welle-Strand and Thune (2009) who explain that there are two types of illiteracy; *functional* and *absolute illiteracy*. Functional illiteracy occurs when someone officially has learned to read and write but has lost the ability. Flora's figures are based on an assumption that if you have officially learned to write you will be recorded as such. Hence, the numbers we have constructed for Norway, using Vannebo, would include the third group (those who can only replicate using the text in front of them).

Another reason why Flora (1973) arrives at high rates of literacy is because he lists the rate of illiteracy, which he defines the following way: *"percent of population which can neither read nor write"*. Thus, we find that Escosura's (2015) formal definition of literacy; *"the percentage of the population aged 15 years or over who is able to both read and write*" and Flora's definition of illiteracy do not mirror one another, as Floras definition of literacy would describe those who can either read or write.

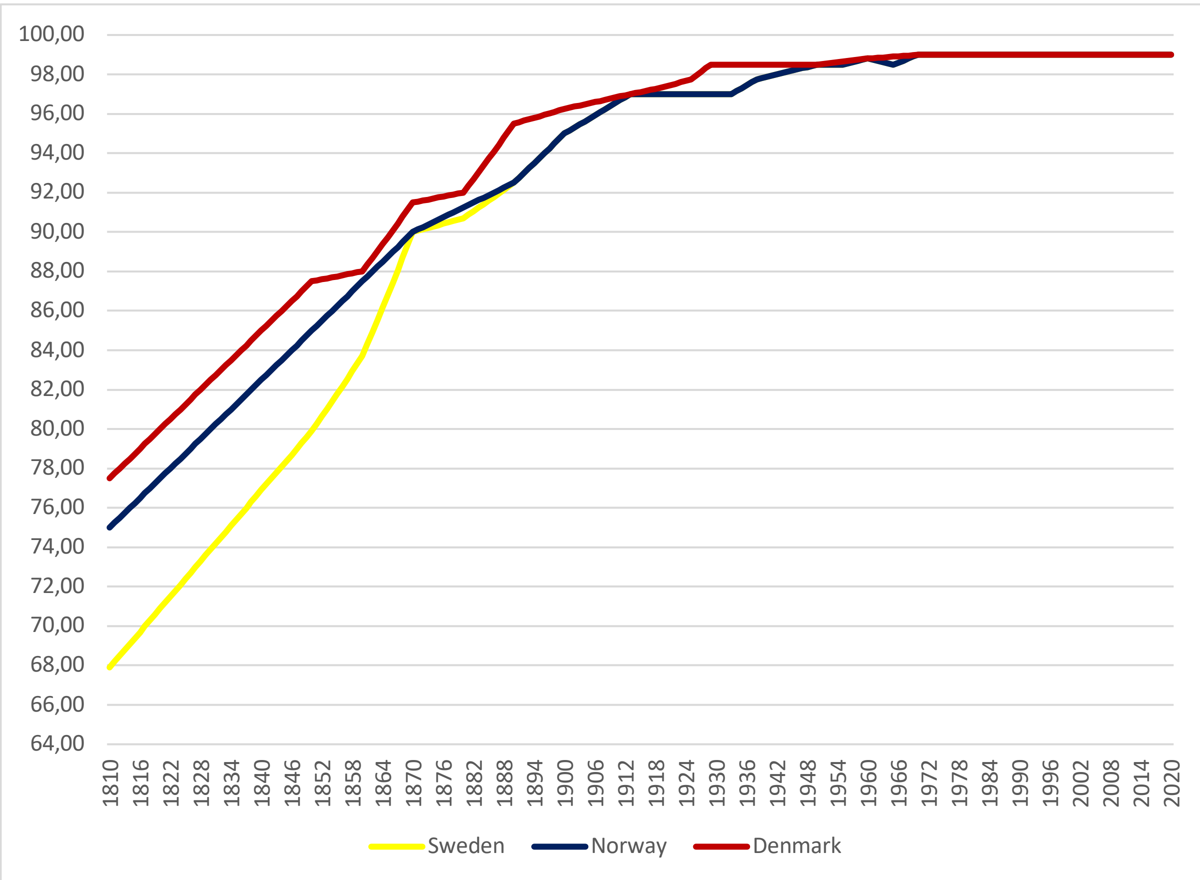
Despite this discrepancy Escosura uses Flora's figures. Hence, he is probably including those who could read but not write in his calculations. However, for the reason of comparison we apply corresponding numbers on literacy as benchmark years. From then on, we apply an annualised log-linear model reflecting the compound growth rates between the benchmark years.

With this in mind and the fact that both Denmark, with its geographical advantage, and Norway, with its Haugean educational influence in the 19th century, seems to be ahead of Sweden in terms of writing ability, we construct literacy rates with these attributes:

- At a level where they would be comparable with the numbers of Escosura.
- Reflecting the development between the Scandinavian countries, where Denmark had the lead followed by Norway, then Sweden.

Hence, we use the basis of the numbers we calculated in the benchmark years and splice them with Escosura's in 1870. From 1900 and onwards the numbers are annualised by log-linear calculations reflecting the compound rates of growth.

Figure 4.6: Comparable literacy rates for Denmark, Norway and Sweden 1814-2020.



(Escosura, 2015; Flora, 1973)

We can see that at the beginning of the 19th century the three countries had different starting points but converged with time. From 1970 all three reache the cap of 99% literacy within their respective countries.

4.6.5 Validity of Literacy rates

Using the numbers of Johansson, Vannebo and Markussen, we believe these numbers to be representative and, thus, valid for our research. However, the numbers of Escosura seem to be based on of the illiteracy rates of Flora. Hence, they will measure a part of the population that could read and not write. This will be slightly invalid considering the definition of literacy as having both skills. However, since these numbers already have been used by Escosura it is reasonable to assume they would be valid in comparisons with the series from other countries and the established definitions in this research area. Thus, they are valid for our research.

4.6.6 Reliability Literacy rates

The annual series of literacy are calculated on the basis of assumptions reflecting on the historical ground development. A weak point would be the annualised log-linear interpolations, which make the series smoother than they would be in reality. It is important to notice that literacy traditionally had no universal definition. In the Scandinavian countries it was historically common to define literacy as those able to read, and not account for writing abilities. Later the United Nations defined literacy as being able to both read and write. However, there is probably no better way to make these estimates on the basis of the knowledge available. Thus, for our research purpose they are reliable, but their reliability seems weaker than the validity.

5. Calculating HIHD

5.1 Introduction

Having established valid and reliable series for the indicators compromising the HIHD in the previous chapter, we are now in a position to construct the HIHD indices for Denmark, Norway and Sweden from 1820 to 2019. The final series enable us to answer the analytical question this thesis rises.

We describe the method used for calculating the HIHD in chapter 3.2: *How to calculate HIHD*. This includes the indices for all three dimensions, including both of education's sub dimensions. Further, in this chapter, we apply this method to our data from chapter 4 to calculate our HIHDs.

5.2 Calculation procedure

In this section we will illustrate how these indices are calculated practically. Norway in the year 1996 will be used as an example for our calculations.

5.2.1 GDP

To be able to calculate the income index, we have to take into account that GDP per capita does not have an ultimate top or bottom value. Thus, we have to calculate the index the same way as in the HDI:

$$Dimension\ Index = \frac{Actual\ Value - Minimum\ Value}{Maximum\ Value - Minimum\ Value} \quad (17)$$

This is the same as:

$$I_{Income} = \frac{x - M_0}{M - M_0} \quad (18)$$

Each variable in the expression should be expressed in logs to describe relative development:

$$I_{Income} = \frac{log\ (x) - log\ (M_0)}{log\ (M) - log\ (M_0)} \quad (19)$$

From here on, Escosura uses the following goalposts:

M = G-K $46 949

M_0 = G-K $100

These we can put into the equation (19) as fixed parameters:

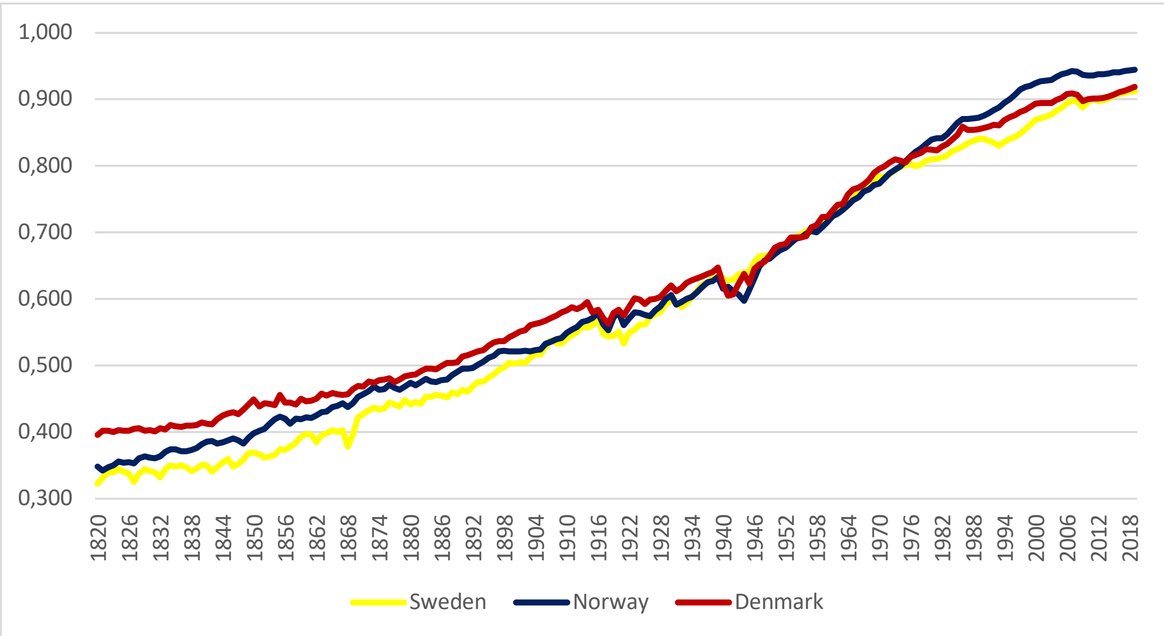
$$I_{Income} = \frac{log\ (x) - log\ (\$100)}{log\ (\$46\,949) - log\ (\$100)} \tag{20}$$

As case we add the value for Norway in 1996. Thus, we set $26 584.6292 in for the parameter x:

$$I_{Income} = \frac{log\ (\$26\,584.6292) - log\ (\$100)}{log\ (\$46\,949) - log\ (\$100)} = 0.908 \tag{21}$$

From there-on-out, we will do the same for observation of GDP per capita for the three countries, arriving at the development depicted in figure 5.1.

Figure 5.1: Income index for Denmark, Norway and Sweden from 1820 to 2019.



(Author's calculations).

The graph shows that Denmark was the leading country with Norway second until all three countries seemed to converge in the 1940s. From around 1940 to 1946 we can see that Sweden takes a leading role. This seems plausible since both Norway and Denmark were occupied in the second world war. From there on out, they seem to move rather similarly until Norway goes slightly ahead from the 1980s onward.

5.2.2 Life expectancy

To calculate time series for longevity, or life expectancy, we use the following equation:

$$I_{Longevity} = \frac{log(M-M_0) - log(M-x)}{log(M-M_0)} \tag{22}$$

From there on, Escosura defines his minimum point as 25 years (M). Also, the Human Development Report kept its goalposts at 25 and 85 years (Escosura, 2015). Hence, we use the same goalposts of the maximum (M) and the minimum (M_0). This interval serves as a fixed parameter for the equation:

$$I_{Longevity} = \frac{log(85-25) - log(85-x)}{log(85-25)} \tag{23}$$

where:

$M = 85$

$M_0 = 25$

Thereafter, we retrieve the life expectancy for Norway in 1996, which is 78.05 years. We insert it into the equation and receive an index of 0.526 for Norway in 1996:

$$I_{Longevity} = \frac{log(85-25) - log(85-78.05)}{log(85-25)} = 0.526 \tag{24}$$

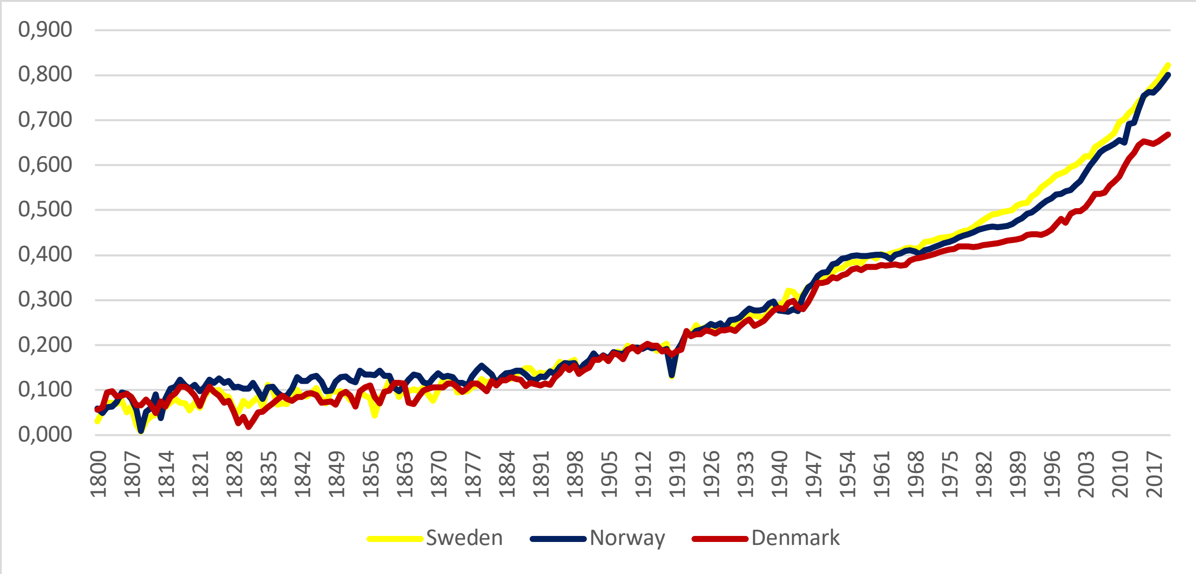
where:

$x = 78.05$

$I_{Longevity} = 0.526$

Thereafter, we calculate for every year 1800-2020, which gives us the following development for Denmark, Norway and Sweden.

Figure 5.2: Life expectancy index for Denmark, Norway and Sweden 1820-2020.



(Author's calculations)

As we can see the countries seem to develop rather similarly. However, Norway and Sweden seem to exceed Denmark around the 1980s until today.

5.2.3 School enrolment

To arrive at an index for school enrolment we first start out with our equation for a human development index:

$$I_{Enrolment} = \frac{log(M-M_0) - log(M-x)}{log(M-M_0)} \tag{25}$$

Escosura states that he uses the values 1, or in our case 100%, as his maximum value, and 0 as his minimum value. Hence M = 100 and M_0 = 0. This assumption will last for every year we calculate the indices for, making them constants. We can plot this into the equation the following way:

$$I_{Enrolment} = \frac{log(100-0) - log(100-x)}{log(100-0)} \tag{26}$$

where:

M = 100

M_0 = 0

Our x will be the enrolment rate for Norway in 1996. Thus, x = 88.34. This gives us:

$$I_{Enrolment} = \frac{log(100-0) - log(100-88.34)}{log(100-0)} = 0.467 \quad (27)$$

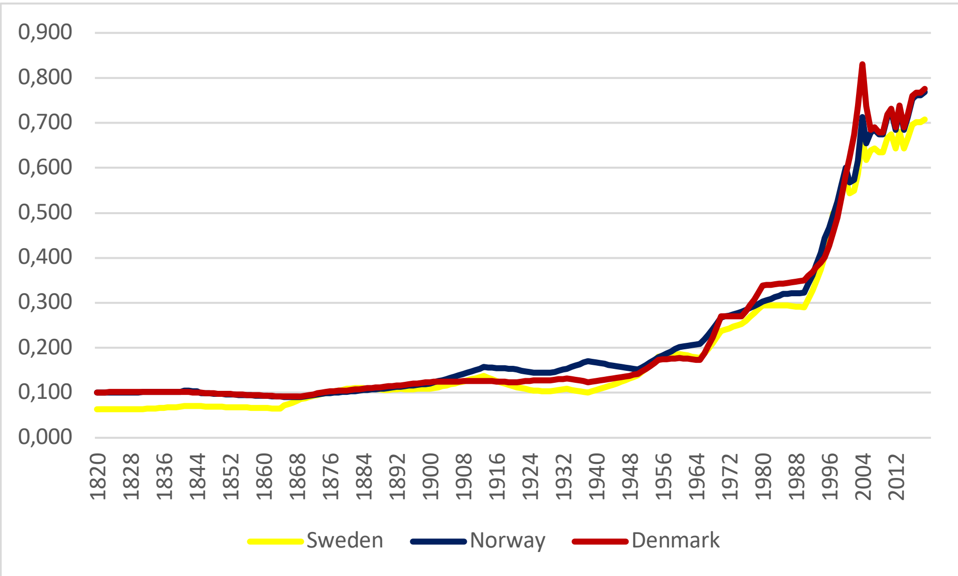
where:

x = 88.34

$I_{Enrolment} = 0.467$

We conduct the same calculations for the three countries for each year. This gives us the development shown in figure 5.3.

Figure 5.3: Enrolment index for Denmark, Norway and Sweden 1820-2020



(Author's calculations).

From this index we can see the development being rather similar across the three countries. However, Sweden starts off at a lower point, and seems to be slightly below for the majority of the time. We can see that the index for Denmark has a sudden deviation from its trend where it surpasses 0.8 and reaches 0.830 in 2004.

5.2.4 Literacy rates

For literacy rates we also start out with the first initial equation for the indices:

$$I_{Literacy} = \frac{log(M-M_0) - log(M-x)}{log(M-M_0)} \qquad (28)$$

Also, for this indicator Escosura, and hence we, use the maximum (M) 100 and the minimum (M_0) 0. Thus, we can write the formula the following way for each year with M and M_0 being constants:

$$I_{Literacy} = \frac{log(100-0) - log(100-x)}{log(100-0)} \qquad (29)$$

where:

M = 100

M_0 = 0

Further, we insert a number for x. In 1996, Norway had a literacy rate of 99%. Hence x = 99. We insert this into the equation and get:

$$I_{Literacy} = \frac{log(100-0) - log(100-99)}{log(100-0)} = 1 \qquad (30)$$

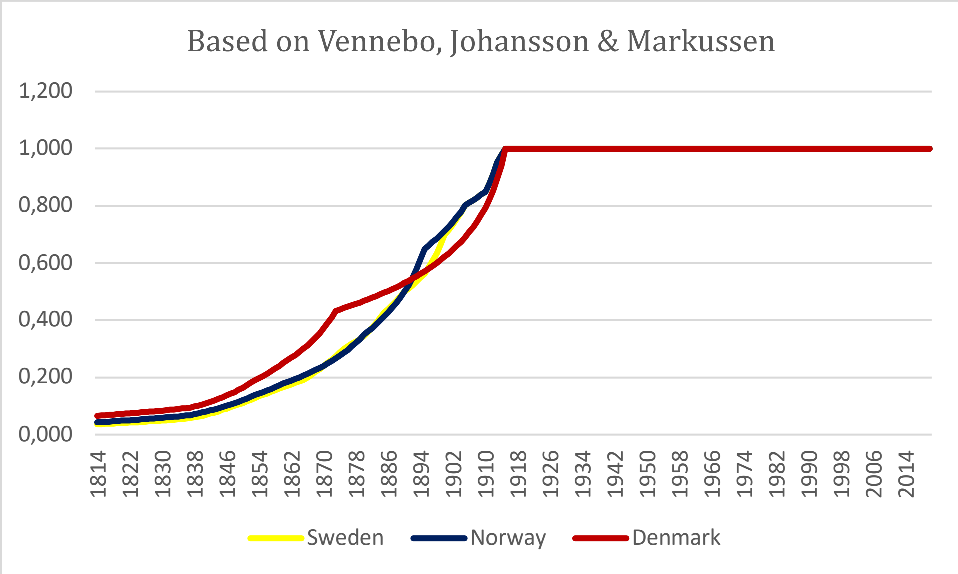
where:

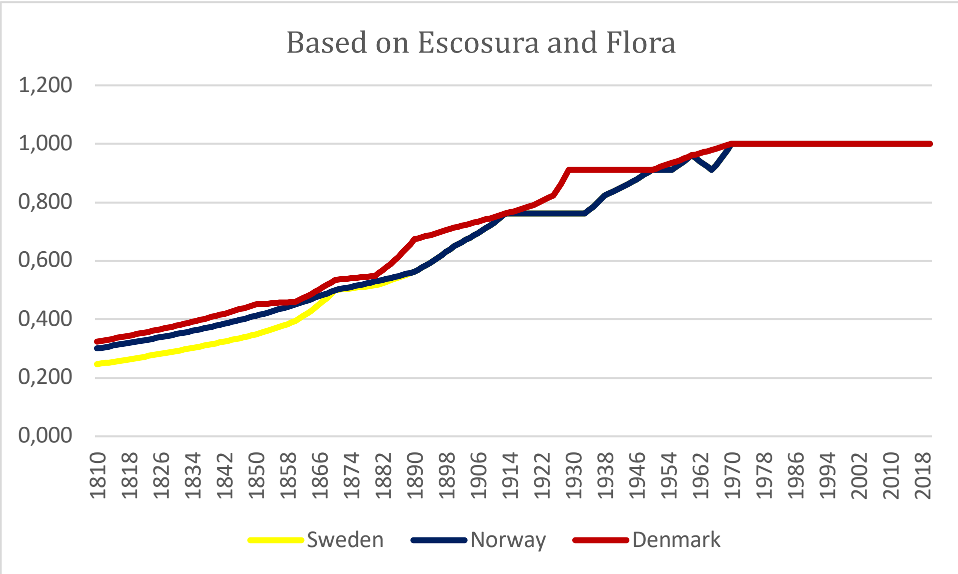
x = 99

$I_{Literacy}$ = 1

However, we have calculated two sets of literacy rates. The one based on the rates of Escosura and Flora and the ones based on Vannebo, Johansson and Markussen. Hence, we calculated two sets of literacy rate indices which we further will use to calculate two sets of education indices and two sets of HIHDs. Both sets reach 1 for Norway in 1996 so the calculation above will be the same for both time series.

Figure 5.4: Literacy indices for Denmark, Norway and Sweden 1814-2020





(Author's calculations).

As we can see the upper series starts at a lower level than that of Escosura and Flora. This is mostly due to the fact that Flora's numbers also include those who could read and not write. However, the numbers of Vannebo, Johansson and Markussen reach a level of 99% literacy way ahead of those of Escosura. Having these differences in mind it is beneficial to include both sets in calculating indices. This way we can identify their effect on the final result.

5.2.5 Combined education index

To acquire a time series for the education indices we have to use an equally weighted geometric mean of the literacy and the enrolment index, as is illustrated in the equation:

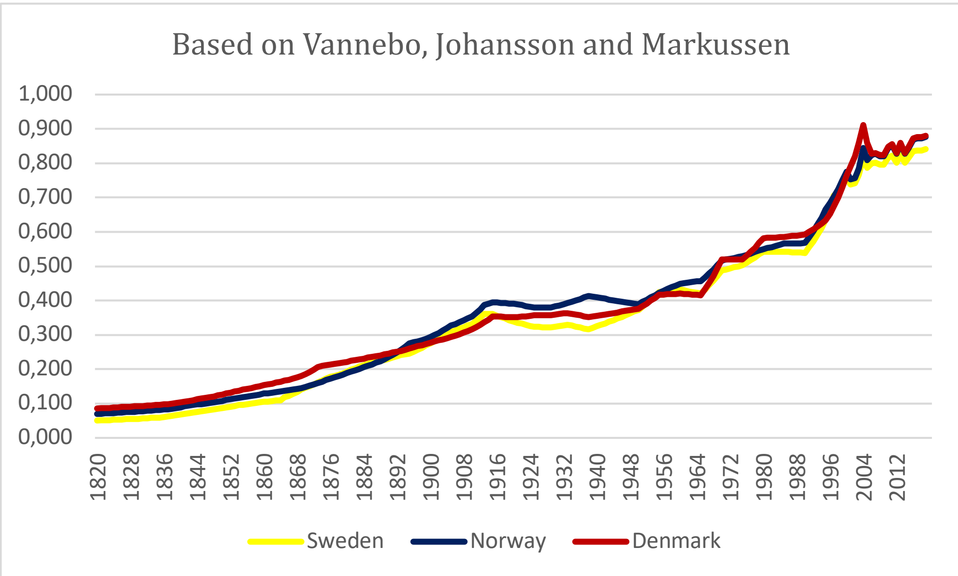
$$I_{Education} = (I_{Literacy} * I_{Enrolment})^{1/2} \qquad (31)$$

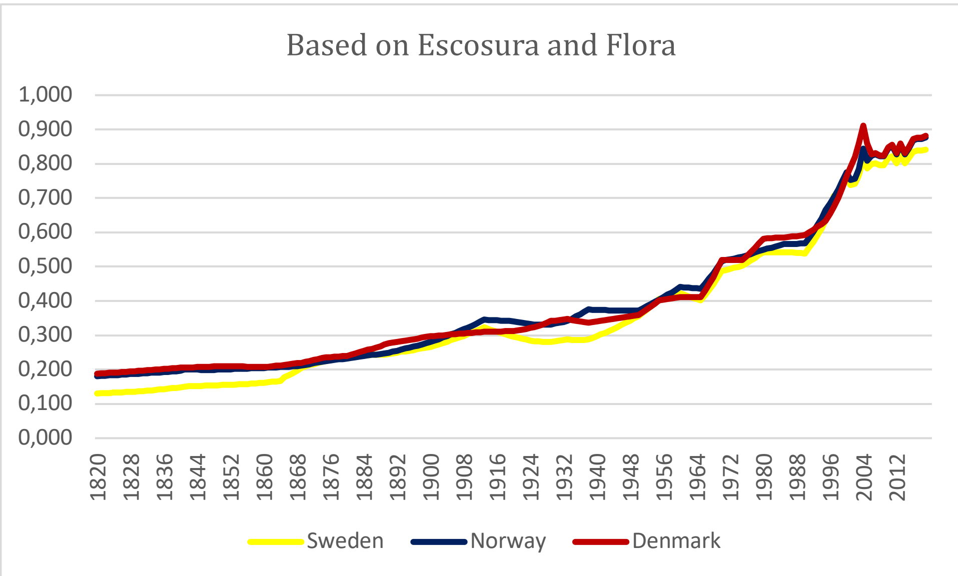
We already have indices for Norway in 1996 where $I_{Literacy} = 1$ and $I_{Enrolment} = 0.467$. We can insert these into the formula above to arrive at our index for education for Norway in 1996:

$$I_{Education} = (1 * 0.467)^{1/2} = 0.683 \qquad (32)$$

This gives us an education index of $I_{Education} = 0.683$ for 1996, as reported in figure 5.5.

Figure 5.5: Education indices for Denmark, Norway and Sweden 1820-2020.





(Author's calculations).

The largest difference among the two sets is that the series based on Vannebo, Johasson and Markussen start at a lower level than those based on Escosura and Flora. Also, the series based on Escosura and Flora place Sweden at a lower level relative to Denmark and Norway.

5.3 Calculations of HIHD

To calculate the combined result, the HIHD, for all three dimensions we need to find the equally weighted geometric average of the numbers. Hence, we will use Escosura's method:

$$HIHD = (I_{Health} * I_{Education} * I_{Income})^{1/3} \tag{33}$$

Further, we insert the different indices we have already calculated into the formula. In our example we will continue to use the numbers for Norway in 1996:

$$HIHD = (0.526 * 0.683 * 0.908)^{1/3} = 0.689 \tag{34}$$

where:

$I_{Longevity} = 0.526$

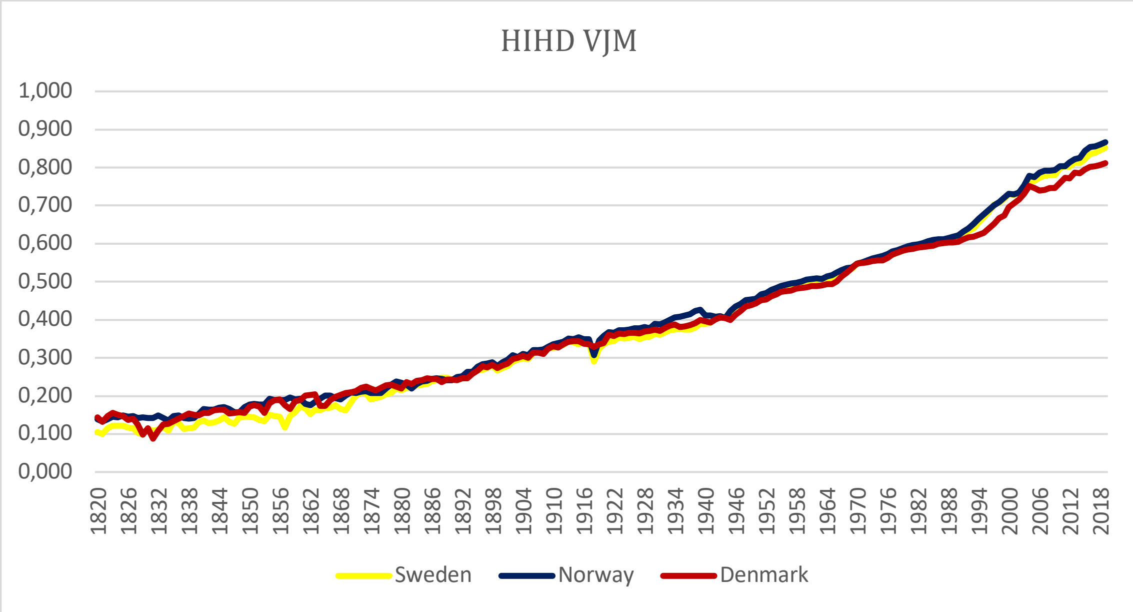
$I_{Education} = 0.683$

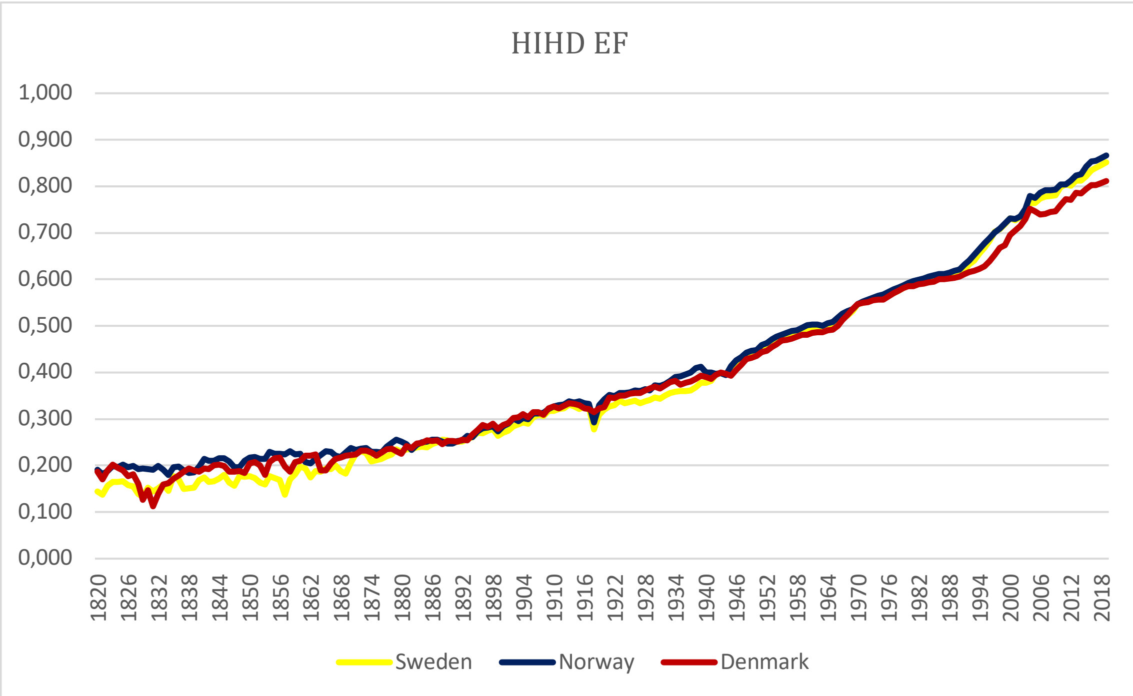
$I_{Income} = 0.908$

HIHD = 0.689

Since we have calculated two kinds of literacy rates, we also have two series of HIHDs. The one with literacy rates based on Vannebo, Johansson and Markussen is denoted VJM. The one based on Escosura and Flora we denote EF. Hence, we come out with two sets of series, which answers the first research problem of this thesis, i.e., mapping human development through the construction of HIHDs for Denmark, Norway and Sweden from 1820 to 2019. Figure 5.6 illustrates the development of both data sets, while table 5.1 presents HIHD for selected key years.

Figure 5.6: HIHD for Denmark, Norway and Sweden from 1820 to 2019.





(Author's calculations).

Table 5.1: Historical Index of Human Development (HIHD) from 1820 to 2019 (key years). For the full dataset which includes every year please go to table A1.1, appendix A1.

	HIHD EF			HIHD VJM		
	Sweden	**Norway**	**Denmark**	**Sweden**	**Norway**	**Denmark**
1820	0.144	0.191	0.187	0.105	0.139	0.144
1830	0.152	0.192	0.147	0.113	0.143	0.114
1840	0.169	0.197	0.186	0.130	0.152	0.149
1850	0.177	0.217	0.204	0.146	0.177	0.172
1860	0.198	0.225	0.210	0.172	0.193	0.190
1870	0.206	0.237	0.223	0.183	0.210	0.210
1880	0.230	0.252	0.226	0.215	0.235	0.220
1890	0.248	0.247	0.253	0.243	0.242	0.243
1900	0.271	0.284	0.287	0.274	0.288	0.280
1913	0.331	0.338	0.333	0.344	0.351	0.342
1925	0.336	0.357	0.355	0.352	0.374	0.366
1929	0.340	0.362	0.365	0.356	0.378	0.371
1933	0.356	0.383	0.379	0.373	0.400	0.385
1938	0.368	0.410	0.386	0.380	0.424	0.392
1950	0.441	0.448	0.436	0.448	0.455	0.443
1955	0.477	0.481	0.469	0.485	0.488	0.474
1960	0.493	0.502	0.481	0.496	0.505	0.484
1965	0.500	0.509	0.491	0.508	0.517	0.493
1970	0.547	0.548	0.547	0.547	0.547	0.547
1975	0.562	0.568	0.557	0.563	0.568	0.557
1980	0.588	0.593	0.585	0.588	0.593	0.585
1985	0.604	0.609	0.596	0.604	0.609	0.595
1990	0.616	0.621	0.605	0.616	0.621	0.605
1995	0.668	0.678	0.629	0.668	0.678	0.629
2000	0.732	0.731	0.696	0.732	0.731	0.696
2005	0.764	0.775	0.746	0.764	0.775	0.746
2007	0.778	0.791	0.741	0.778	0.791	0.741
2010	0.798	0.803	0.760	0.798	0.803	0.760
2015	0.822	0.843	0.795	0.822	0.843	0.795
2019	0.852	0.866	0.811	0.852	0.866	0.811

(Author's calculations)

By comparing the two sets of HIHDs we conclude that they have a similar development despite starting off at different levels, with the VJM starting off at a slightly lower level. The VJM set finally surpass the EF series in the time frame 1894-1908. Norway is the first country where this happens, with $Norway_{VJM}$ surpassing $Norway_{EF}$ in 1894. In Sweden it happened in 1898 and in Denmark this happened in 1908. In 1980, however, the EF dataset catches up to the VJM set again.

6. Comparative Analysis

6.1 Introduction

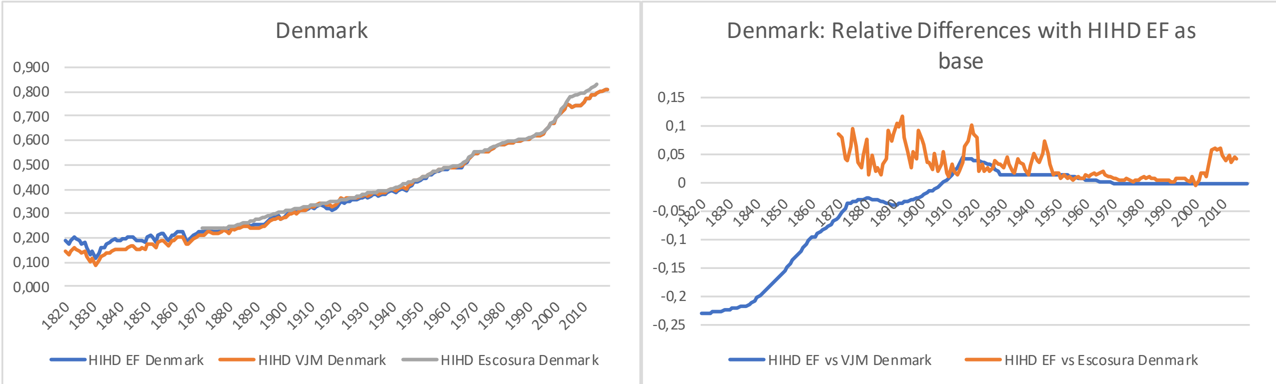
In order to conclude on the historical level of human development in the Scandinavian countries it is imperative to compare the newly calculated HIHD series with previous ones, in order to find out how significant the revisions are. In addition, it is imperative to compare our Scandinavian HIHD series with HIHD series for other countries, as this might serve to illustrate relative wellbeing and human development cross border historically.

6.2 Comparison with existing HIHDs

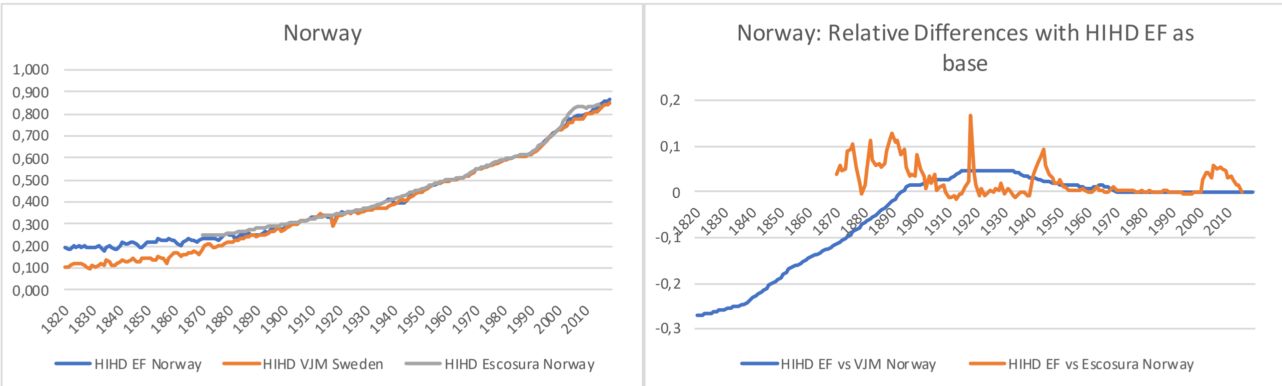
To compare the new HIHDs with existing ones, we have put our VJM and EF HIHDs in the same graph as the HIHDs of Escosura for each country. However, the rates of Escosura only contain benchmark years around every tenth or fifth year, when our series contain estimates for each year.

To make comparable series we have calculated annualised log-linear compound growth rates between the rates of Escosura. This gives us the ability to examine annual developments. We examine the differences among the three time-series for each country.

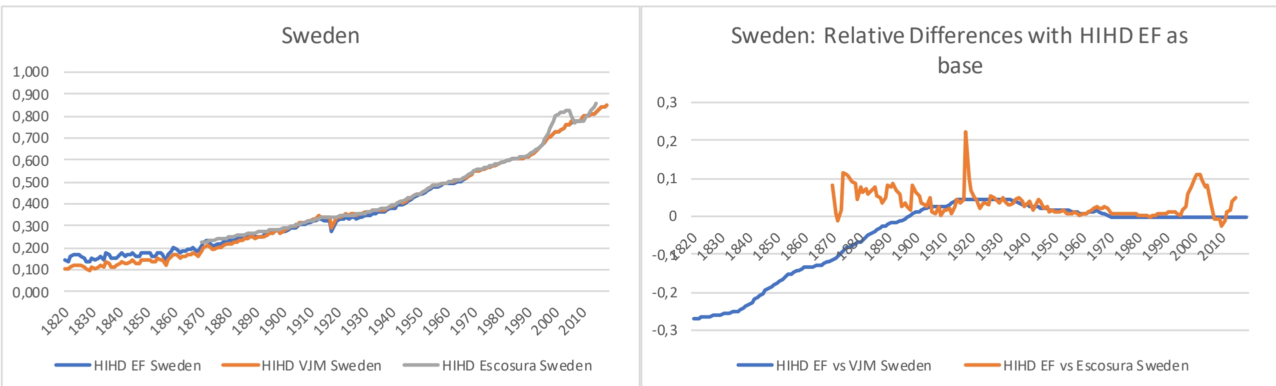
Figure 6.1: To the left we present the HIHD comparisons between new and existing HIHDs, Scandinavia. To the right we present the deviations from the HIHD EF.



(Espacio Investiga, 2019; and author's calculations).



(Espacio Investiga, 2019; and author's calculations).



(Espacio Investiga, 2019; and author's calculations).

The figures to the left demonstrate the gradual development which seems quite uniform in the long run. However, when we look at annual differences between the series measured as deviations from the HIHD EF data set, we see that the HIHD VJM starts below but later passes the HIHD EF in the late 1800s. They converge towards 1970 and from then on have the exact same development. Escosura's numbers fluctuate more and are above our numbers most of the time until the 1960s. After 2000 Escosura's numbers start fluctuating again. These fluctuations reflect that the statistical basis of his series is weaker than the new series presented here.

For the most part we can see that all the three sets of indices are quite similar. Until 1870 we can see that our indices based on literacy rates from Escosura and Flora outperform our indices with literacy rates from Vannebo, Johansson and Markussen, 1820-1870. From 1870 however, these two sets of time-series have converged, with the EF-rates still being slightly ahead. The rates of Escosura seem to be ahead our rates until around 1900s. From then on until the 2000s they alternate on showing highest values. The exception is Norway, where Escosura's seem to be below our rates. In the 2000s to 2015 each country seems to have a different development. Escosura's rates for Sweden fluctuate a lot for the last year, while the new series are more stable. In the beginning Escosura's rates for Norway diverge from our rates, going beyond, before they converge to the same level. As for Denmark, the rates of Escosura seem to establish themselves at a higher level.

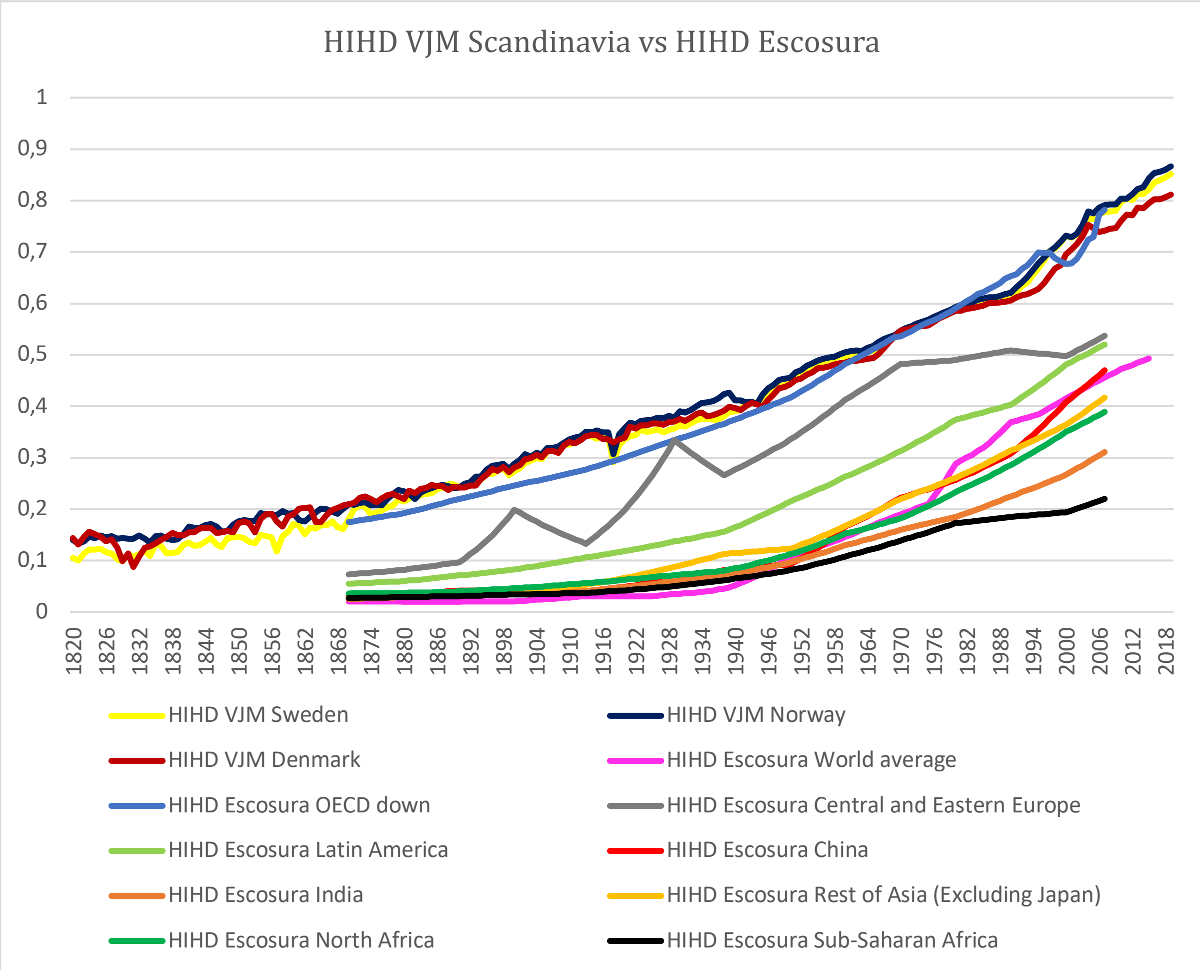
6.3 Comparison with international HIHDs

In this section we will compare our two sets of series of HIHDs to the HIHDs by Escosura (2015). He provides time series for OECD, Central and Eastern Europe (which includes Russia), Latin America, China, India, the Rest of Asia (excluding Japan), North Africa and Sub-Saharan Africa. For these numbers we acquire rates for 1870, 1880, 1890, 1900, 1913, 1929, 1938, 1950, 1960, 1970, 1980, 1990, 2000 and 2007. These serve as benchmark years for us to find annualised log-linear developments as compound growth rates between the benchmarks. We also report Escosura's world average HIHD. We follow the same procedure of calculating the compound growth rate for these series.

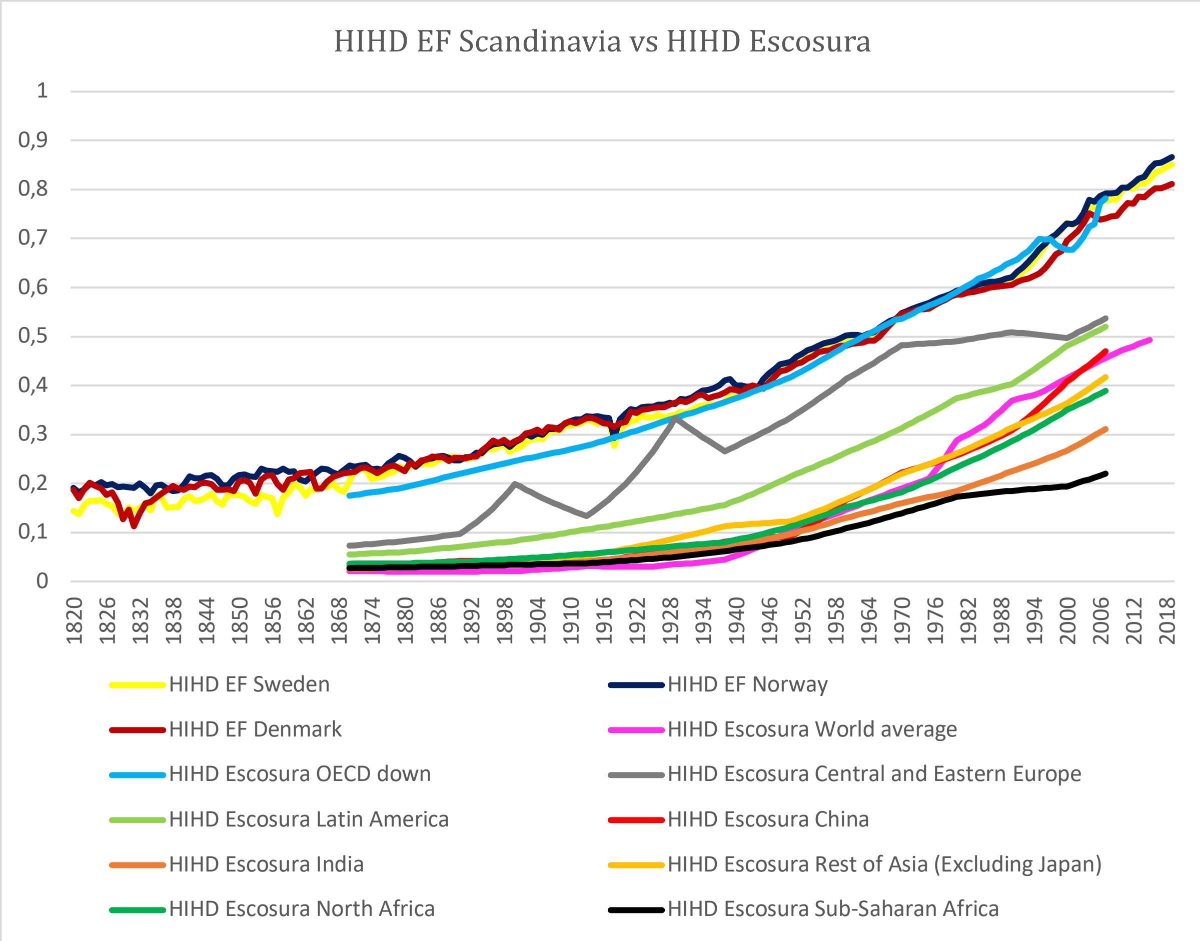
For Escosura's OECD rates, we need to slightly down-scale his numbers for 1970-2007. This is mostly because our series for Norway, Sweden and Denmark give lower HIHDs than those of Escosura, due to more updated data on literacy rates. Hence, we adjust the OECD HIHDs with a similar factor 1970-2007.

We present all these series in two graphs, one using our HIHD VJM series and the other the HIHD EF series. These are presented in figure 6.2.

Figure 6.2: Comparison of new HIHD for Scandinavia compared to existing international HIHD.



(Escosura, 2015; Espacio Investiga, 2019; author's calculations)



(Escosura, 2015; Espacio Investiga, 2019; own calculations)

As we can see the majority of the differences between our two sets of HIHDs seem to appear before 1870. We will for most of the discussion further refer to them as our HIHDs or simply use the HIHD EF as reference point if there are no significant differences we should point out. Also, the HIHD EF's values are, as mentioned, more based on the values of Escosura than the HIHD VJM. In consequence, we would deem them more suitable to be used for comparisons with other series from Escosura.

First, we will compare the Scandinavian countries to one another. The graphs and their development tell us that for the most part Norway and Sweden were quite even during most of the 19th century. Thereafter they were quite similar until around 1980, when Norway surpassed the others. These results are to some extent surprising. Writers on Scandinavian economic history have almost unanimously concluded that Denmark was by clear margin the wealthiest countries in the nineteenth century, when our figures show that human development, as proxy of economic wellbeing, conclude that Norway was at the same level. This was due to significantly higher life expectancy in Norway. This is probably one of the most significant results of our analysis.

From both graphs we can conclude that Norway, Sweden and Denmark have been doing well in terms of human development compared to the rest of the world. As we can spot from the figure, the Scandinavian neighbours have, not surprisingly, been doing better than areas like Central and Eastern Europe, Latin America, China, India, the rest of Asia, Northern and Sub-Saharan Africa. For most of their recent history they seem to have either been above or at the same level as the OECD countries. Hence, they have been doing better or as good as the wealthiest countries in the world. Despite being around the same level as the OECD countries in recent years, they are often ranked among the best countries to live in.

In other words, our calculations show that all the three Scandinavian countries already during the 19^{th} century had obtained human development as a proxy of economic wellbeing and development in line with the wealthiest countries of the world. As for Denmark and Norway, it was even higher.

6.4 Short term development

From the graphs and time series above we get the impression that the development of Norway, Sweden and Denmark seems to be almost identical in the long run. To test short term uniformity, we conduct a correlation analysis where we will set up a correlation matrix between the three countries. Since the long-term development is increasing for all countries the numbers are clearly autocorrelated and need to be made stationary. We choose two methods of accomplishing this. The first one implies we find cycles around a polynomial trend, reporting when the observations are over and under the trend, we find how they deviate from a stationary proxy. The second method involves looking at annual changes to adjust for most of the autocorrelation.

By making a time series stationary by looking at deviations (cycles) from trends, one in fact detrends the series. In order to do so, we use the Hodrick-Prescott filter. To further see how HP filters are constructed see chapter A4 in the appendix.

High smoothing parameters give trends with minor fluctuations, and thus, significant cycles. A smoothing parameter equal to zero means that changes in the observed series should be explained by trend developments only. Thus, high smoothing parameters make cycles decisive components in time series. Low smoothing parameters give trends with large fluctuations, and thus, minor cycles. Rules of thumb suggest a smoothing-parameter of λ = 100 for annual figures, λ = 1,600 for quarterly figures, and λ = 14,400 for monthly figures. In line with similar analysis for business cycles, we have chosen to use a smoothing parameter of 2500 for our annual HIHD series (Grytten, 2019).

For the correlation coefficient of the annual growth, we first logged both sets of HIHD. Thereafter, we subtracted the previous year from the year of investigation, as stated in equation 35:

$$logdx_{(t-(t-1))} = log(x_t) - log(x_{t-1}) \tag{35}$$

where $logdx_{(t-(t-1))}$ = annual changes in x

x_t = observed value at period t

x_{t-1} = observed value at previous period

log = natural logarithm

By doing these two operations we arrive at stationary series, which enable us to carry out our correlation analysis, as reported in table 6.1

Table 6.1: Correlation coefficients on HIHD cycles for 1820-2019, 1820-1873, 1873-1914, 1914-1945, 1945-2019 and annual changes for the same time periods.

	HIHD EF	HIHD VJM	Annual Changes HIHD EF	Annual Changes HIHD VJM
Sweden & Norway	0.450	0.446	0.569	0.569
Sweden & Denmark	0.449	0.469	0.392	0.395
Norway & Denmark	0.217	0.225	0.169	0.167
1820-1873				
Sweden & Norway	0.323	0.336	0.519	0.521
Sweden & Denmark	0.428	0.450	0.389	0.393
Norway & Denmark	0.113	0.134	0.112	0.113
1873-1914				
Sweden & Norway	0.651	0.590	0.616	0.608
Sweden & Denmark	0.537	0.575	0.422	0.407
Norway & Denmark	0.556	0.549	0.401	0.400
1914-1945				
Sweden & Norway	0.756	0.759	0.898	0.897
Sweden & Denmark	0.600	0.684	0.487	0.483
Norway & Denmark	0.680	0.692	0.476	0.483
1945-2019				
Sweden & Norway	0.928	0.919	0.696	0.668
Sweden & Denmark	0.766	0.758	0.629	0.609
Norway & Denmark	0.775	0.751	0.416	0.386

(Author's Calculations)

First, we note that the two different sets of HIHD, EF and VJM, both seem to give us rather similar results in terms of correlation between the different countries. We find the correlation coefficients between Norway and Denmark surprisingly low, when the correlation coefficients between Sweden and Norway are high. This suggests that short-term human development is far more interlinked for Sweden and Norway than for Norway and Denmark, when the Sweden-Denmark short-term relationship seems to be in between the two top and bottom relationships.

If we divide the development into the periods 1820-1873, 1873-1914, 1914-1945 and 1945-2019 we can see that the correlation is increasing the closer one gets to 2019. We can see that the very low correlation between Norway and Denmark is a result of very low correlation in the time period 1820-1873. This most likely results from a large decrease in life expectancy in Denmark in the 1830s. If we correct for this by calculating the correlation between Norway and Denmark from 1850-2019, we get the numbers 0.297 (EF) and 0.285 (VJM). Despite this we can conclude that the correlation is highest for Norway and Sweden, and that it increases for all with time.

6.5. Findings

The comparative analysis of our new series reveals several important features:

1. All Scandinavian countries were at least at the OECD average in their HIHDs both in the 19th and 20th century, while most writers in economic history seem to have believed that Sweden was somewhat below during the 19th century.
2. The new calculations suggest that both Denmark and Norway were clearly above the OECD average during the 19th century. This is not surprisingly for Denmark, while Norway scores higher than many would assume.
3. The Norwegian 19th century HIHD is at the same level as the Danish, suggesting that economic development and wellbeing was at the same level for the two countries, which is contrary to the understanding held by most economic historians, who based on the limited understanding GDP figures have provided, have concluded Denmark was significantly better off then Norway
4. Norway did astonishingly well during the 19th century due to long life expectancy rates.
5. Sweden was clearly inferior to Denmark and Norway within writing skills during the first half of the 19th century, which made their HIHD fall relative to their Scandinavian neighbours.
6. All three countries did well during the entire 20th century even compared to the wealthy OECD.
7. The short run development was significantly more uniform between Sweden and Norway than between Denmark and Norway.

7. The Relationship between GDP and HIHD

7.1 Introduction

One of the research questions we try to answer in this thesis is how well economic growth reflects Human development. This chapter will focus around that question. Therefore, we will try to figure out whether GDP per capita is a good measurement of human development in the short and long term?

GDP per capita is often used as a measure of the wealth of a country and an indicator of a country's development. By comparing the HIHD to the logged GDP per capita we can discover how well these correlates with each other. The analysis contains plot diagrams and regressions in order to identify how well the two series statistically relate to each other. In our analysis we will use the HIHD EF numbers, which are most in line with the established international HIHDs of Escosura.

7.2 Comparison with GDP per capita

Since GDP per capita often is used for measuring wealth and economic development it is natural that we compare it with the HIHD, which is seen as both an indicator of human development and economic development. We want to find out if a high level of GDP correlates with a high HIHD score. In order to illustrate this, we have constructed four plot diagrams for our HIHD EF on the y-axis and logged the GDP per capita on the x-axis.

We find the estimated regression line of the plots of the diagrams for each country. By logging the figures with their natural logarithms (ln) we account for the percentage growth in both of them. The regression model can be stated as in equation (36):

$$HIHD = a + \beta Y_{cap} + e \qquad (36)$$

The logged model would look the following way:

$$HIHD = \alpha + \beta\log(Y_{cap}) + e \quad (37)$$

where

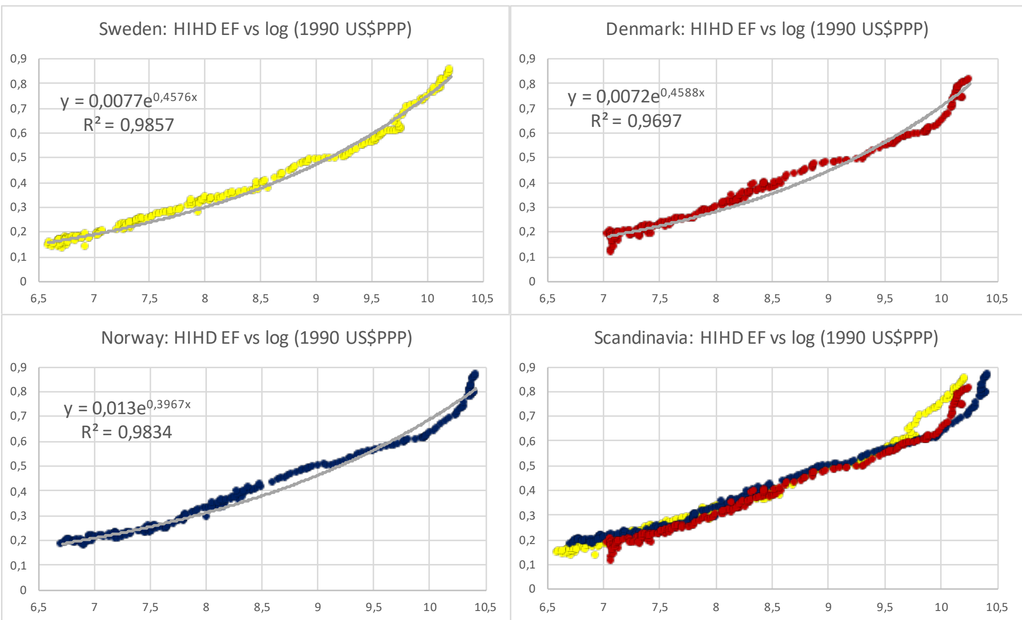
α = intercept

Y_{cap} = GDP per capita

e = disturbance term

This provides us with regression lines in the plot diagrams, (where HIHD is denoted y since its presented at the y-axis and GDP per capita is denoted x since it is presented at the x-axis):

Figure 7.1: Plot diagrams and regression lines for HIHD vs logged GDP per capita.

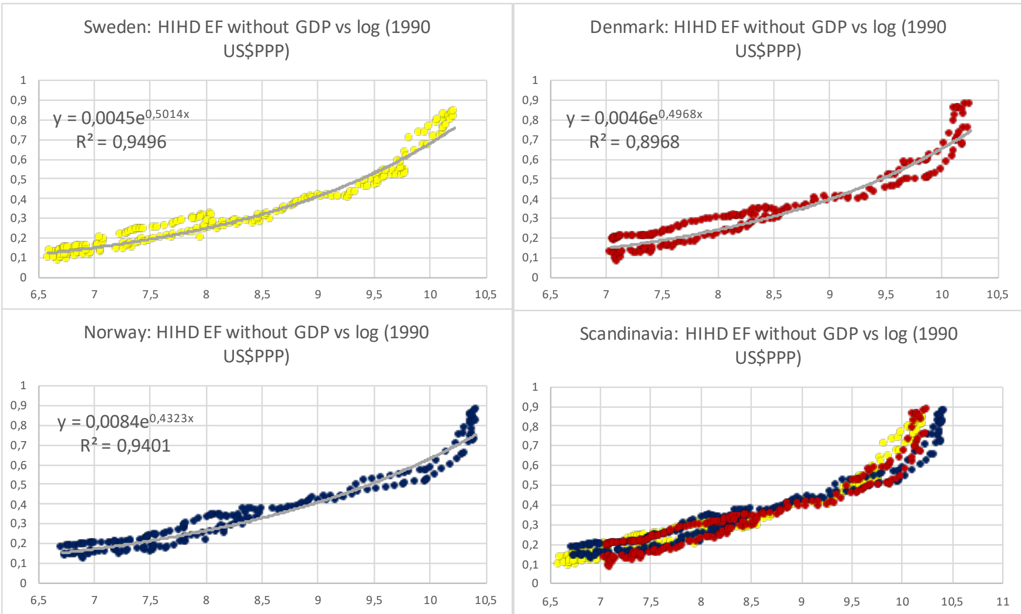


The equations tell us that when GDP per capita increases by one percent, the HIHD for Denmark, Sweden and Norway increases by 0.4588, 0.4576 and 0.3967 respectively. The determination coefficients, R^2, are also very high, between 0.9697 and 0.9857, which means that the regressed lines can explain between 96.97% and 98.57% of the development. This means there is a clear long-term statistical relationship between the variables. We are of course aware of autocorrelation in the series. However, here we are interested in finding how the long-term growth patterns correlate, and thus, autocorrelation is a natural part of it.

7.3 GDP per capita vs reduced HIHD

We also want to figure out how this development would look if we made HIHDs without the GDP per capita indicator, including only the two social variables. Hence, we take the geometric average of the dimensions: education and life expectancy. Thereafter, we plot these rates into a scattered diagram against the logged GDP per capita. This gives us the following results, as reported in figure 7.2:

Figure 7.2: Plot diagrams and regression lines for reduced HIHD vs logged GDP per capita.



The regression lines depict regression coefficients, which are only slightly lower than when GDP per capita was included in the HIHD, with 0.5014 for Sweden, 0.4968 for Denmark and 0.4323 for Norway. The largest difference is seen in the determination coefficients, R^2s, which fall down to levels between 0.8968 and 0.9401. This reflects that life expectancy and education are less volatile than GDP per capita. Thus, one gets a smoother reduced HIHD, which does not account for the GDP fluctuations in the same way as the full HIHD.

7.4 Short term correlations

Short term-movements are of course also of importance when looking for links between HIHD and GDP per capita. In order to do that we need to make our series stationary. We accomplish this the same way as in appendix A4. Thus, we first find the polynomial trends of our series and thereafter the deviations between the annual values and the corresponding trend, as previously stated in equation (38):

$$log\ (c_t) = \ log\ (x_t) - log\ (g_t) \tag{38}$$

where

c = cycle component

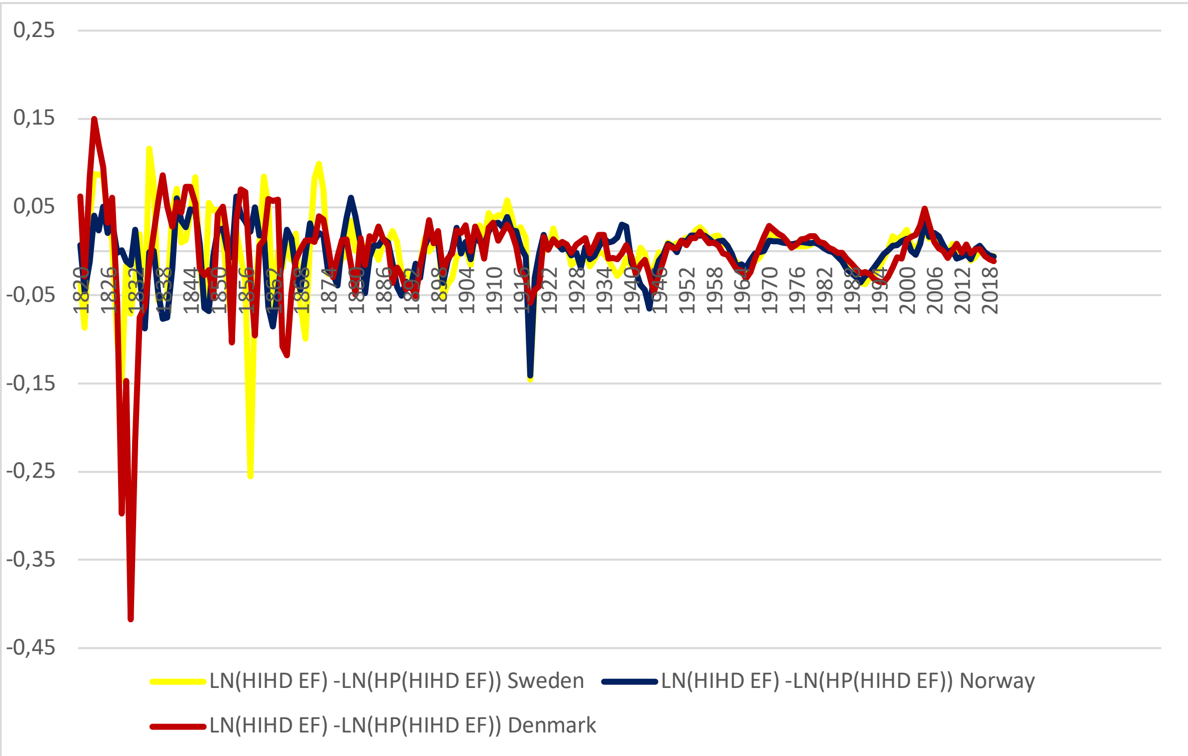
x = observation value

g = trend

t = period

Again, we follow the international literature (Grytten, 2019) and use lambda value 2500 as smoothing parameter for both GDP per capita and HIHD for the three Scandinavian countries under investigation. The logged cycle values of both GDP per capita and HIHD are shown in figure 7.3.

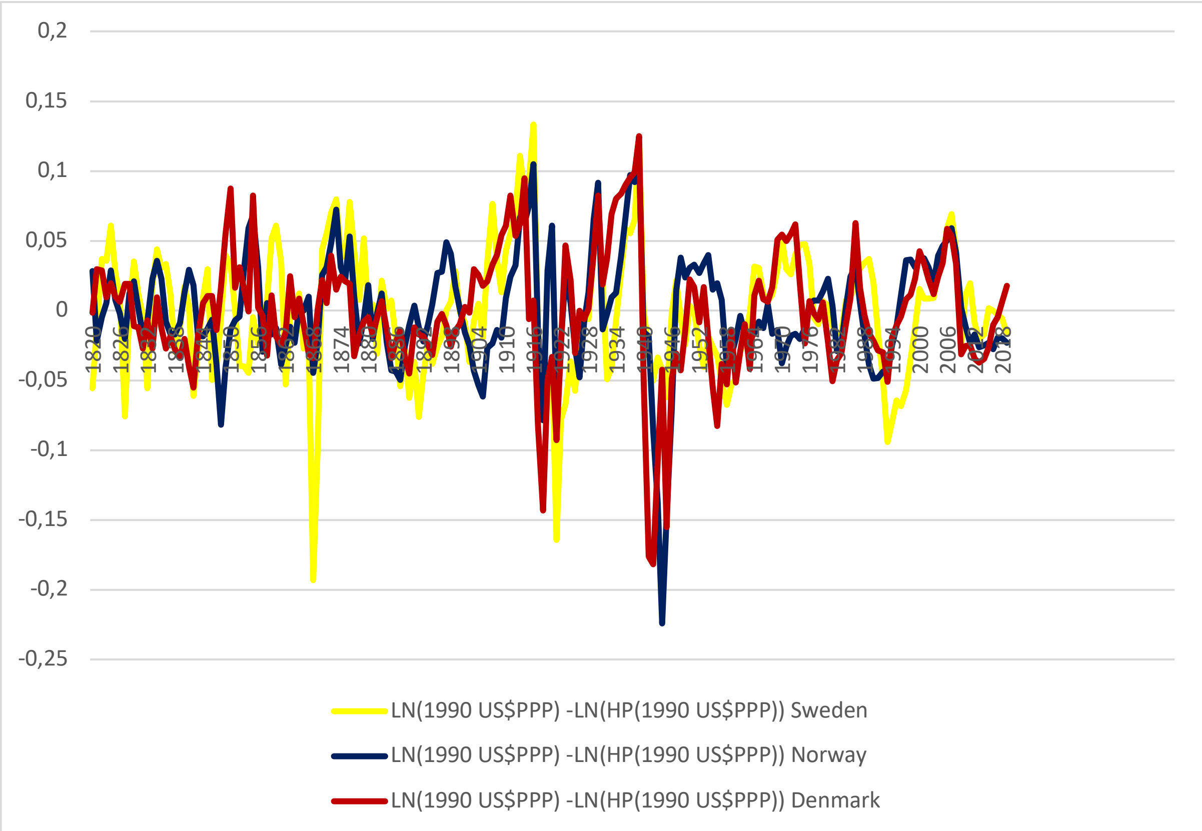
Figure 7.3: HIHD log cycles for Denmark, Norway and Sweden from 1820 to 2019 (lambda =2500).



(Based on series from chapter 4 and calculations from chapter 5).

The large trough for Denmark in the late 1820s to mid 1830s is caused by a decline in their life expectancy over those years. For the majority of the time period 1790-1900 all of Scandinavia had declining death rates and stagnant birth rates (Søbye, 2015). However, the mortality rate still would fluctuate before stabilising with time. Out of the three countries Denmark had the largest urban population and was, therefore, the most exposed to the epidemic diseases which arrived in Europe in the 1820s and 1830s. This gave a high infant mortality rate (Folkehelseinstituttet, 2014).

Figure 7.4: GDP per capita log cycles for Denmark, Norway and Sweden from 1820 to 2019 (lambda = 2500).



(Based on series from chapter 4 and calculations from chapter 5).

For the trends on GDP per capita we can see particularly for the interwar and war periods that the deviations were significant for all three countries. For the first world war we can see that the development for Sweden and Denmark was mostly negative. However, Norway seems to have benefited from it, likely due to the fact that they made profits from trade during the war.

Having made our series stationary, we are now in a position to calculate meaningful correlations between HIHD and GDP per capita from 1820 to 2019. We find correlations for the entire period and seven sub-periods, i.e., 1820-2019, 1820-1873, 1873-1914, 1914-1945 and 1945-2019. These periods are chosen on the basis of the major economic and historical events of these years. In 1873 the long depression started in Europe. 1914 marks the start of the first world war and 1945 the end of the second world war, while 2019 marks last year.

We also tried to adjust our two series for two different scenarios, the first being the possibility of GDP per capita affecting the social variables of HIHD, education and life expectancy. To calculate for these, we gave GDP per capita a 1, 2, 3, and 5-year leads where its time series started in 1820 and ended in 2018, 2017, 2016 and 2014 respectively. The series for HIHD ended in 2019 and started in 1821, 1822, 1823 and 1825 respectively. We then gave the HIHD the lead to see whether or not the social variables had an effect on GDP per capita. We followed the same procedure and gave HIHD a 1, 2, 3, and 5-year leads. Starting in 1820 and ending in 2018, 2017, 2016 and 2014 respectively. The GDP per capita then all ended in 2019 and started in 1821, 1822, 1823 and 1825 respectively.

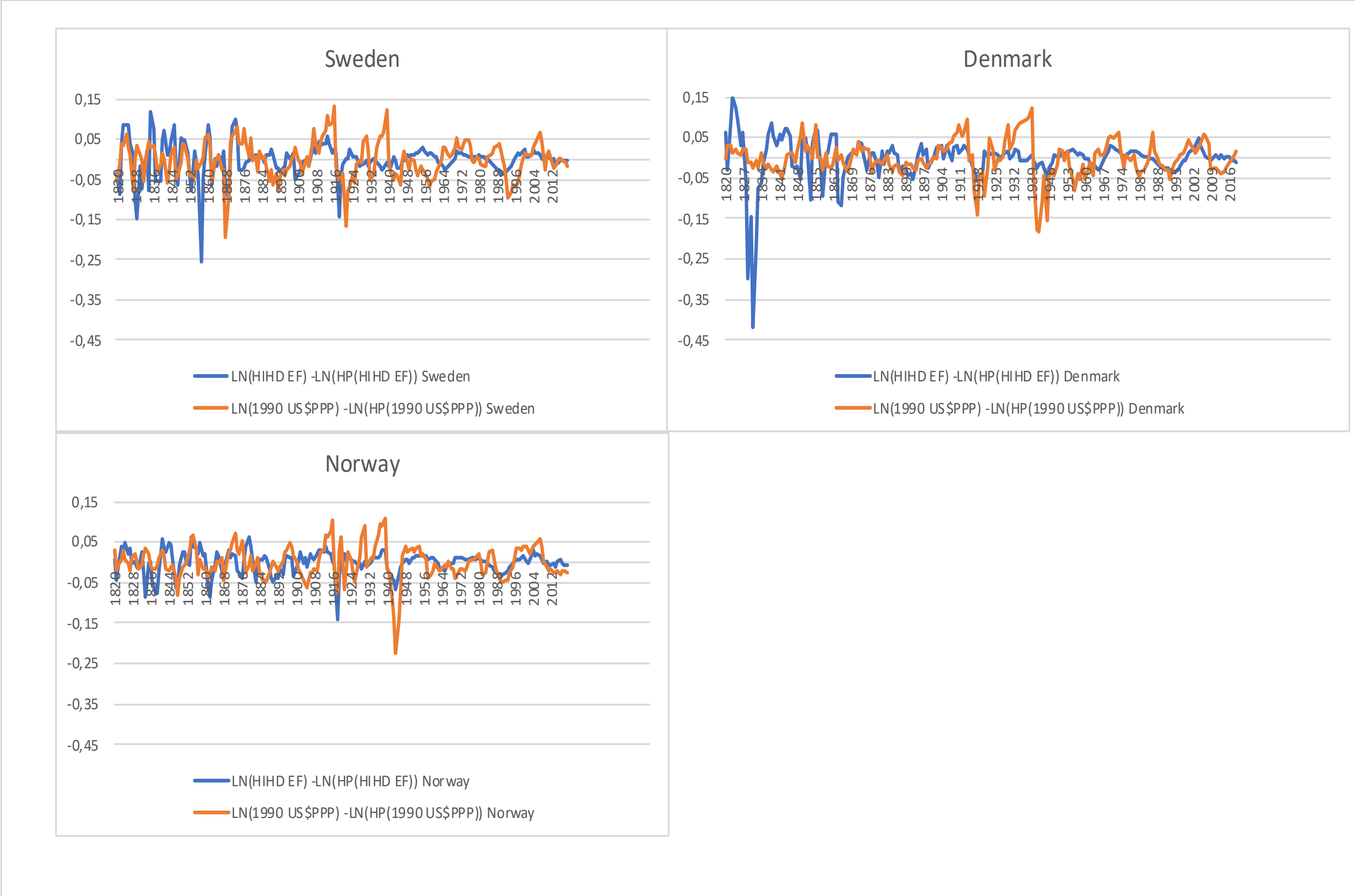
This gives us the correlation coefficients which are listed in table 7.1. We have also added the developments of HIHD and GDP in figure 7.5 to illustrate the point.

Table 7.1: Correlation coefficients HIHD EF and GDP per capita from 1820 to 2019.

	Sweden	Norway	Denmark	Lag/lead
1820-2019	0.309	0.401	0.326*	t
1820-1873	0.460	0.427	0.179	t
1873-1914	0.501	0.081	0.424	t
1914-1945	0.202	0.634	0.616	t
1945-2019	0.070	0.606	0.384	t
1820-2019	0.244	0.270	0.130	HIHD t+1 lag
1820-2019	-0.018	0.086	0.081	HIHD t+2 lag
1820-2019	-0.138	0.028	0.015	HIHD t+3 lag
1820-2019	-0.082	-0.102	-0.027	HIHD t+5 lag
1820-2019	0.150	0.293	0.156	HIHD t-1 lead
1820-2019	-0.003	0.188	0.126	HIHD t-2 lead
1820-2019	0.054	0.136	0.083	HIHD t-3 lead
1820-2019	0.107	-0.089	0.055	HIHD t-5 lead

*Adjusted for noise in life expectancy rate in 1830s, i.e. abnormally high mortality rates due to epidemics in the large cities (Two standard deviations as upper and lower bounds).
(Based on series from chapter 4 and calculations from chapter 5).

Figure 7.5: Cycles of GDP per capita and HIHD.



(Based on series from chapter 4 and calculations from chapter 5).

The correlations are highest for the simultaneous observations, with Norway at the top. The sub-period 1914-1945 stands out as the years with the highest combined correlation coefficients, with the exception of Sweden. This shows there is short-term correlation between GDP per capita and HIHD. However, the correlation coefficients are not very high, due to the fact that the GDP per capita parameter is significantly more volatile than the education and life expectancy parameters.

7.5 Findings

All in all, we can conclude that there is an obvious long-term and short-term correlation between GDP per capita and HIHD. However, the coefficients are not as high as one perhaps would expect. This is an indication that the GDP has a limited value as an indicator of human development or economic development in a broad sense. At least when discussing the development of wellbeing, standard of living and human development, GDP is far from a sufficient measure, while the HIHD seems to be more holistic and thus more informative.

8. Contribution by dimensions

8.1 Introduction

The third question our research problem raised, was how much each parameter contributes to the HIHD. In other words, how much did the three different dimensions each contribute to human development.

In this chapter we aim to answering this question quantitatively, by calculating each dimension's share of the HIHD during the time span.

8.2 Recap of the Neo-classical growth model

Calculating the dimensions' contribution to human development has similarities to growth accounting of the production factors' contribution to increase in GDP. In growth accounting the departure is the contribution of capital, labour and multifactor productivity's contribution to economic growth. In human development accounting we find similar factors of growth. The theoretical basis of the Solow-Swan model was discussed in chapter 2. It suggests that output or value added in an economy, measured as GDP, is decided by production factors

$$Y = A * f(K, eL) \tag{1}$$

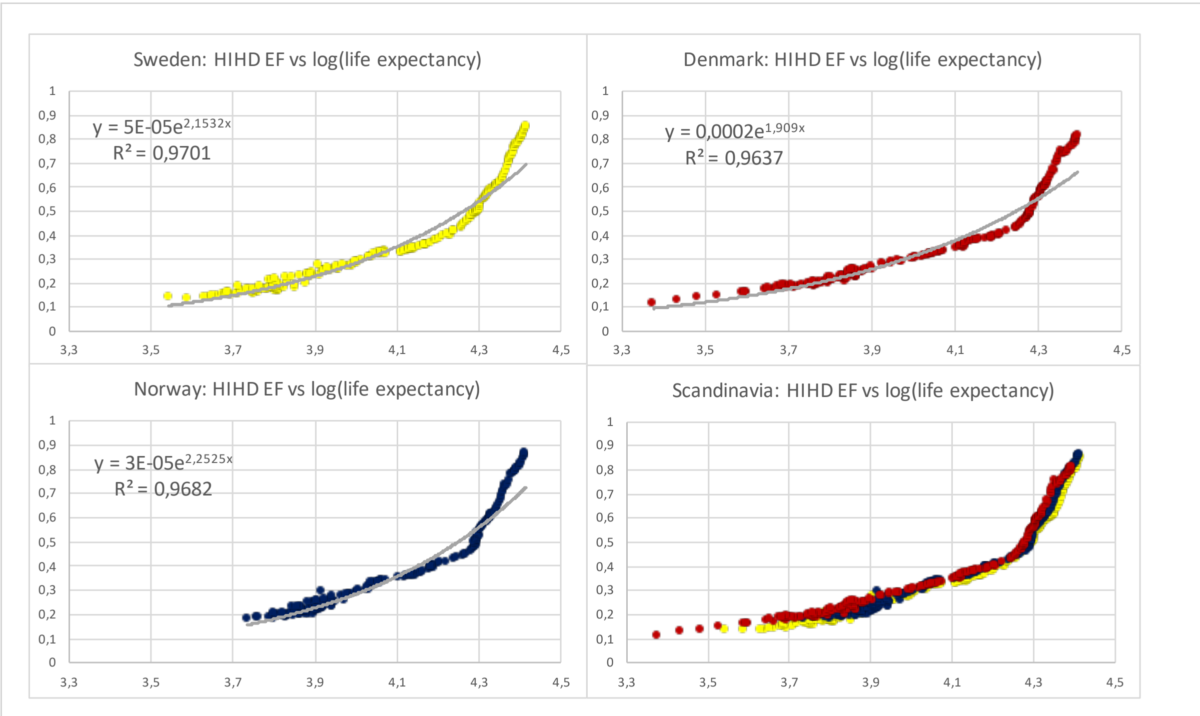
Here Y is output, Capital is denoted (K), labour (L), education (e) and multifactor productivity or ideas (A). Applied on both the HDI and the HIHD, it is natural to claim that GDP reflects capital (K) and Labour (L), school enrolment and literacy reflect education (e), while life expectancy also reflects labour. How these are put together and organised, and how open they are for new ideas and inventions (A), are decisive for growth of the economy and in human development.

8.2.1 Graphical relations

Chapter 7 gave evidence of the statistical relationship between GDP and HIHD. Here we want to map possible similar relationships between HIHD and life expectancy and education, which inform us about the contributions of these dimensions to human development. We do this by presenting plot diagrams with log values and corresponding trend lines calculated as log-linear regressions. The regression coefficients show the statistical relationship between the x and y axis parameters as showed in equations (36) and (37) in chapter 7. However, GDP is here substituted with life expectancy, enrolment rates and literacy rates.

Hence, figure 8.1. depicts relationships between HIHD and life expectancy, measured by life expectancy at birth. Figure 8.2 depicts relationships between HIHD and education, measured by enrolment rates and literacy rates for Denmark, Norway and Sweden.

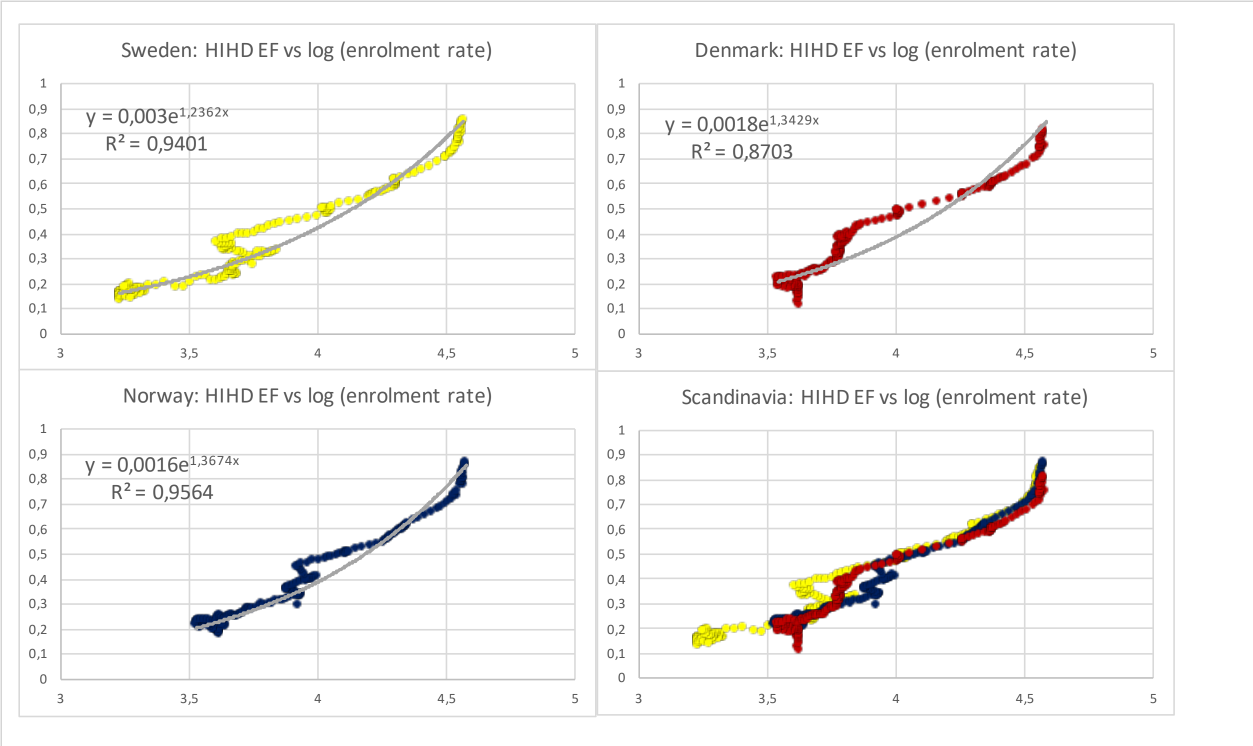
Figure 8.1: Relationship HIHD EF vs logged life expectancy for Denmark, Norway and Sweden from 1820 to 2019.

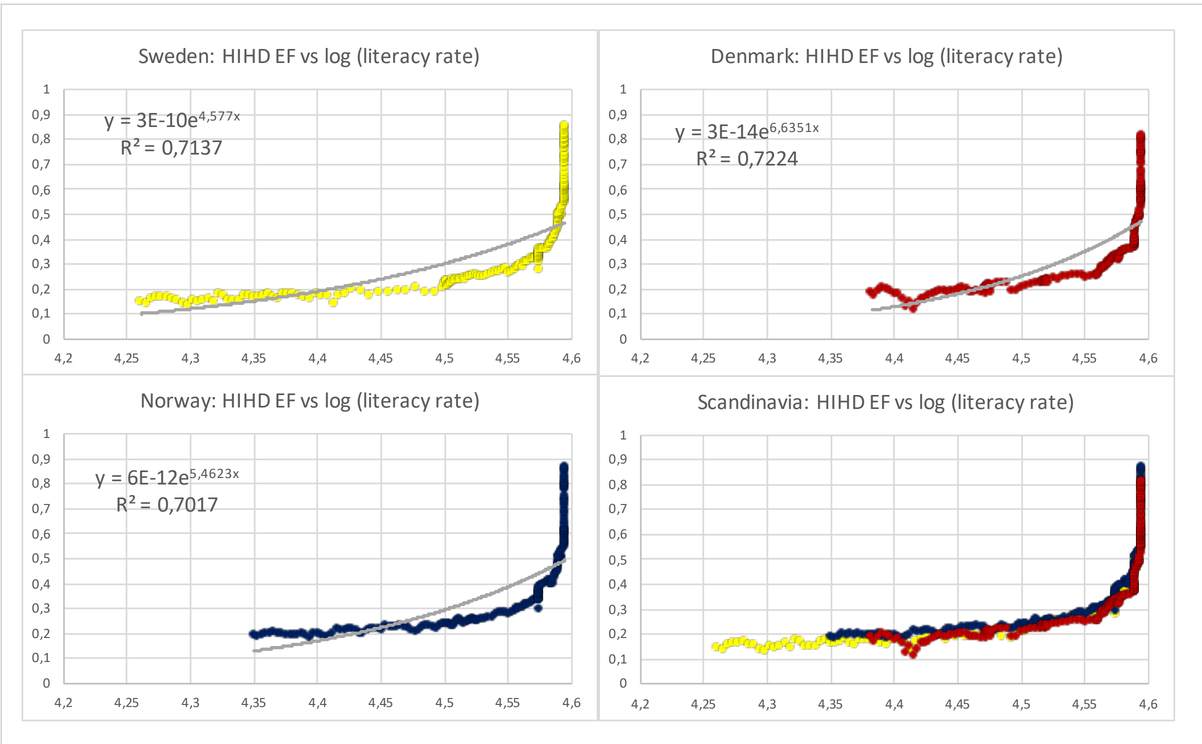


As one can see the relationship is very strong and the determination coefficients, R^2 are significant. The relationships are quite similar for all three countries. However, Denmark has a slightly lower regression coefficient than the other two, meaning that life expectancy played a slightly less important role for human development in Denmark.

Figure 8.2 draws the corresponding plots for the statistical relationships between HIHD and the indicators for education, i.e., school enrolment rates and literacy rates.

Figure 8.2: Relationship HIHD EF vs logged enrolment rates for Denmark, Norway and Sweden from 1820 to 2019. Relationship HIHD EF vs logged literacy rates for Denmark, Norway and Sweden from 1820 to 2019.





Again, we see strong relationships. For literacy rates the estimates are biased due to the early reach at 99% around 1900. Thus, one gets a vertical slope towards the end of the x-axis, very high regression coefficients and low determination coefficients, between $R^2 = 0.7017$ and $R^2 = 0.7224$. This implies that the regressed line can explain between 70.17 and 72.24 percent of the development. However, the graphs show different patterns for the indicators, and thus a necessity to map their relative contribution to HIHD during the long time series.

8.3 Contribution of indicators

When calculating the dimension's contribution to human development, one has to operationalise the parameters by looking at the indicator's contribution to HIHD.

This can be done by adding the indices for each specific year together. That implies, if we again use Norway 1996 as an example, that we find the income index, the life expectancy index and the education index and add them up to a sum. Thereafter, we divide the index for each indicator representing a dimension for that year on the total sum. In order to use the most internationally comparable figures we use the HIHD EF series built on the same principles as Escosura's series. The calculations will look like this:

$$SUM\ of\ Indices_{Country,Year} = I_{Health} + I_{Education} + I_{Income} \qquad (39)$$

For Norway in 1996 that would be:

$$2.117 = 0.526 + 0.683 + 0.908$$

$$Contribution\ of\ Dimension_{Country,Year} = \frac{I_{Dimension,Country,Year}}{I_{Health}+I_{Education}+I_{Income}} \qquad (40)$$

This implies the following contributions for 1996 by dimensions:

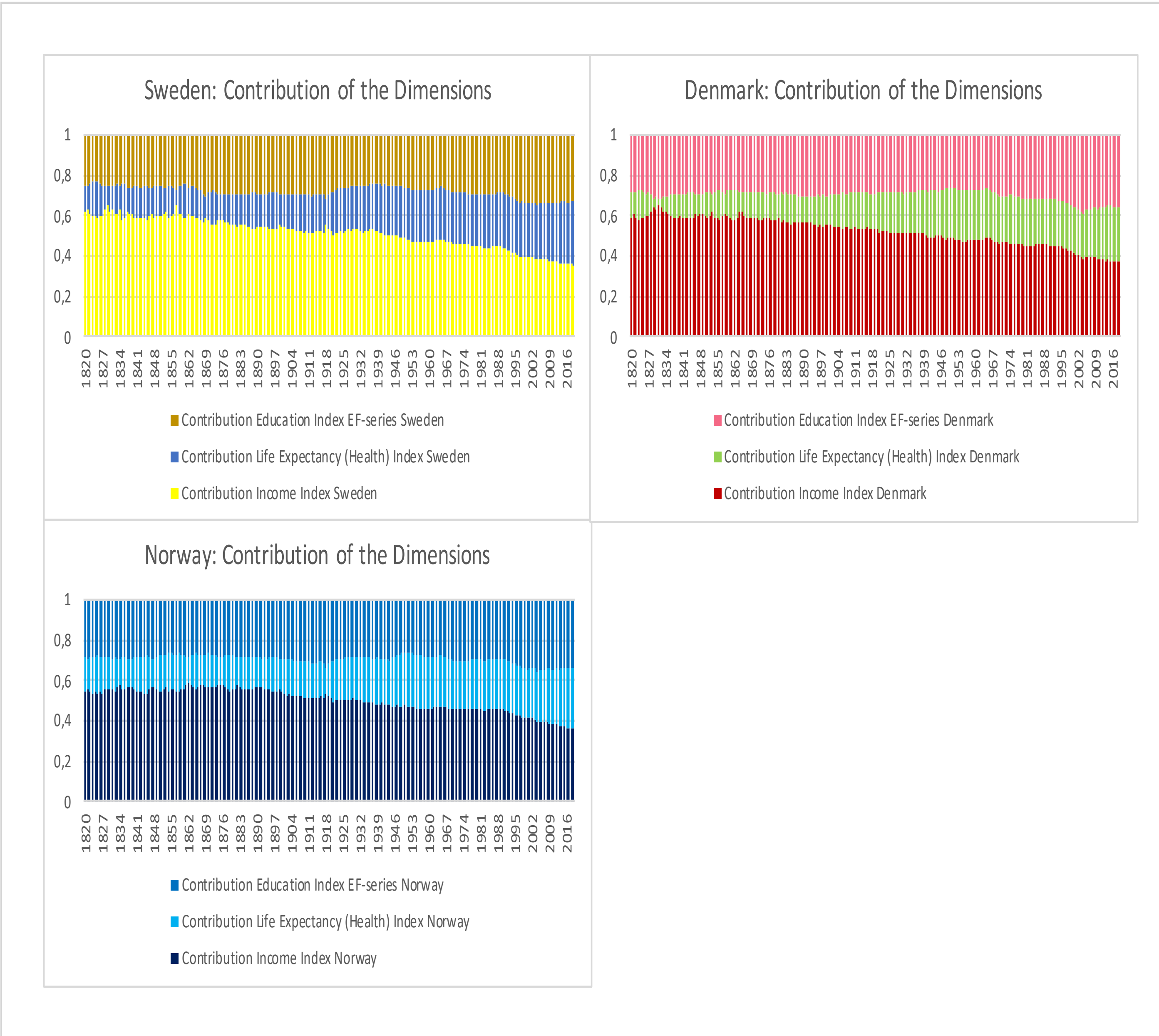
Contribution of Health = 0.526/2.117 = 24.85%

Contribution of Education = 0.683/2.117 = 32.26%

Contribution of Income = 0.908/2.117 = 42.89%

By doing similar calculations for the three countries, one arrives at their contribution to the HIHD from 1820 to 2019. The results are shown in figure 8.3. The results show quite similar patterns for the three countries. The relative contribution from the dimension decent standard of living, denoted income in the figure, and measured by GDP per capita, shows a declining trend for all the three countries. The relative contribution from the knowledge dimension, measured as education, is more stable for all of them, but shows an increasing trend from the mid 20th century. The long and healthy life dimension, measured as life expectancy at birth, shows significant increase in relative contribution to human development for all three countries. For Denmark and Sweden, the life expectancy at birth indicator's relative share is more than doubled between 1820 and 2019, while the increase is lower for Norway, which by far has the longest life expectancy when our series start in 1820.

Figure 8.3: Relative contributions of dimensions (indicators) to HIHD for Denmark, Norway and Sweden from 1820 to 2019.



(Author's calculations)

The results of the calculations are also listed in table 8.1 below, presented for approximately every tenth year from 1820 to 2019. The table also reports decadal growth rates of the dimension's (indicator's) relative growth. By looking at the development for the different dimensions represented with their indicators, we can trace some important findings.

8.3.1 GDP

Through the figures we can see how each of the three dimensions develop in how much they contribute to the index as a full. We observe that for all three countries the income index seems to have been the largest contributor to the HIHD for most of the years. Already in 1820 it contributes 61.5% for Sweden, 54.4% for Norway and 58.9% for Denmark. However, its contribution has since declined. This decline has obviously been present for all three countries but seem to have had a larger impact on Denmark and Sweden which in 2019 reached 35.6% and 37.4% respectively. For them the income index, as we can see from the 1820 results, contributed relatively more than what it did for Norway in the same year. Hence, its decline as their major contributor occurred at a faster pace. For Norway its contribution declined to 36.2% in 2019.

Table 8.1: Relative contribution of indicators to HIHD, Denmark, Norway and Sweden from 1820 to 2019.

Contribution of Indexes

	Sweden			Norway			Denmark		
	Income Index	Life Expectancy Index	Education Index	Income Index	Life Expectancy Index	Education Index	Income Index	Life Expectancy Index	Education Index
1820	0,615	0,136	0,248	0,544	0,174	0,282	0,589	0,131	0,280
1830	0,617	0,137	0,246	0,554	0,159	0,288	0,630	0,063	0,307
1840	0,593	0,157	0,250	0,561	0,151	0,288	0,596	0,109	0,295
1850	0,595	0,156	0,249	0,548	0,177	0,275	0,599	0,120	0,280
1860	0,585	0,178	0,237	0,557	0,173	0,270	0,592	0,132	0,276
1870	0,577	0,135	0,287	0,563	0,171	0,266	0,588	0,132	0,279
1880	0,556	0,145	0,298	0,557	0,170	0,273	0,590	0,119	0,292
1890	0,550	0,160	0,290	0,571	0,141	0,288	0,568	0,125	0,307
1900	0,549	0,161	0,290	0,544	0,164	0,293	0,552	0,147	0,301
1913	0,516	0,186	0,298	0,510	0,178	0,312	0,534	0,184	0,282
1925	0,518	0,221	0,260	0,503	0,208	0,289	0,516	0,203	0,282
1929	0,533	0,214	0,253	0,513	0,204	0,283	0,516	0,196	0,288
1938	0,529	0,230	0,241	0,484	0,226	0,290	0,515	0,214	0,270
1950	0,487	0,257	0,256	0,476	0,259	0,265	0,492	0,248	0,261
1960	0,469	0,256	0,275	0,460	0,257	0,283	0,479	0,248	0,273
1970	0,461	0,252	0,287	0,455	0,242	0,304	0,465	0,232	0,303
1980	0,446	0,255	0,299	0,456	0,245	0,299	0,452	0,229	0,319
1990	0,444	0,272	0,284	0,455	0,250	0,295	0,454	0,232	0,314
2000	0,391	0,268	0,341	0,412	0,243	0,345	0,416	0,229	0,355
2007	0,382	0,278	0,341	0,392	0,264	0,344	0,399	0,237	0,365
2010	0,372	0,289	0,339	0,384	0,269	0,347	0,388	0,247	0,365
2019	0,356	0,315	0,329	0,362	0,301	0,336	0,374	0,268	0,358
1820-1913	-0,099	0,049	0,050	-0,034	0,004	0,030	-0,055	0,053	0,002
1925-1938	0,010	0,009	-0,019	-0,018	0,018	0,000	-0,001	0,012	-0,011
1950-2007	-0,105	0,021	0,084	-0,084	0,005	0,079	-0,093	-0,011	0,104
2007-2019	-0,025	0,037	-0,012	-0,030	0,037	-0,008	-0,025	0,032	-0,007
1913-2000	-0,167	0,117	0,051	-0,152	0,101	0,051	-0,153	0,090	0,064
2000-2019	-0,035	0,047	-0,012	-0,049	0,058	-0,009	-0,042	0,039	0,003
1820-2019	-0,259	0,178	0,080	-0,182	0,127	0,054	-0,216	0,138	0,078

(Author's calculations).

8.3.2 Life expectancy

In terms of life expectancy, or health index, it seemed to be particularly low for Denmark and Sweden at the beginning of the time series. However, there has been a clear relative growth in contribution from then and until now. For Sweden it grows from 13.6% of the contribution in 1820 to 31.5% in 2019. Denmark experienced an increase from 13.1% to 26.8% during the same time frame. The development was slower for Norway. Also, here it starts off as the smallest contributor with 17.4% before it grows to contribute with 30.1% in 2019. Thus, the health index seems to be the fastest growing contributor.

8.3.3 Education

For the education index there are two main observations; firstly, it has shown less relative change among the three dimensions. Secondly, it remains the second largest contributing dimension throughout our time series. In 1820 its contribution was 24.8% for Sweden, 28.2% for Norway and 28.0% for Denmark. It increases to 32.9% for Sweden, 33.6% for Norway and 35.8% for Denmark. In other words, a slow and small increase. Education played a relatively low role for Sweden the first decades of our analysis, while it plays a relatively important role for Denmark towards the end of our period of investigation.

8.4 Findings

In this chapter we seek to examine the relative contribution of the dimensions which make up human development, operationalised with life expectancy, education and GDP per capita. This is done by calculating each indicator's share of their total sum for each year. The results show that GDP per capita (income) was the most important contributor during the entire 200-year period, while education was the second most important. Life expectancy at birth played a smaller role. However, it also shows large growth during the period, while GDP is losing its importance and education increasing moderately. Due to relatively high life expectancy during the 1800s, Norway experienced less relative growth in this dimension's contribution than the others.

9. Conclusions

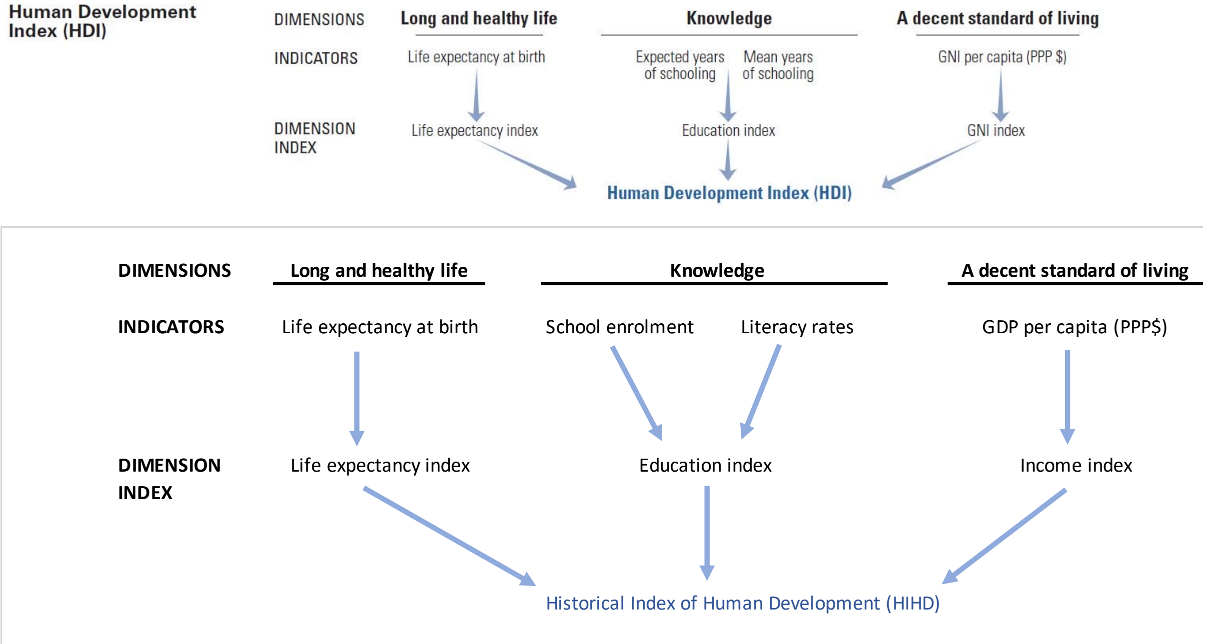
9.1 Summary

The research problem of this thesis is threefold:

1. What were the human development levels for Denmark, Norway and Sweden from 1820 to 2019?
2. How well does economic growth reflect Human development?
3. How much do the parameters of the HIHD contribute to its development?

In order to answer these questions, the main objective has been to construct historical indices of human development (HIHD) for the three countries. This is based on three indicators representing three different dimensions of human development. These are summarised in figure 9.1.

Figure 9.1: Overview of Human development dimensions, indicators and indices for the HDI (upper) and the HIHD (lower).



(Human Development Report, 2019)

While existing HIHDs cover every tenth year since 1870, the new series give annual figures since 1820. Also, the new series have better data coverage than the old ones and should present more precise figures. Thus, we conclude the new HIHD series are more valid and reliable than the previous ones.

After the construction of the new HIHDs we examined both the short and long term relationships between GDP per capita and HIHD by quantitative analysis. The motivation for this is to find out how effective GDP is as a measure of human development, which can also be represented as human wellbeing, standard of living and economic development.

Finally, the thesis seeks to map the relative contribution of the three indicators. This is done by summarising the index-values and calculating each indicator's share. Then we map the development of these shares in absolute and relative terms in order to cast light on their contribution to the HIHD.

9.2 Findings

The analysis concludes the following results displayed under their related research questions below:

1. What were the human development levels for Denmark, Norway and Sweden from 1820 to 2019?
    a. All Scandinavian countries were at least at the OECD average in their HIHDs both in the 19th and 20th centuries, while most writers in economic history seem to have believed that Sweden was below during the 19th century.
    b. The new calculations suggest that both Denmark and Norway were even, clearly above the OECD average during the 19th century. For Denmark, this is not a surprise. At the same time, Norway scores higher than many would assume.
    c. The Norwegian 19th century HIHD is at the same level as the Danish, suggesting that economic development and wellbeing was at the same level for the two countries. This is contrary to the understanding held by most economic historians, who based on the limited understanding GDP figures have concluded that Denmark was significantly better off then Norway.
    d. All three countries did well during the entire 20th century even compared to the wealthy OECD.
    e. The short run development was significantly more uniform between Sweden and Norway than between Denmark and Norway.

2. How well does economic growth reflect Human development?
    a. There is an expected high correlation between long term HIHD and GDP per capita.
    b. Short term correlation is not as strong as the long-term, due to larger fluctuations in GDP than HIHD.
    c. However, GDP per capita does not satisfactorily reflect human development, and thus not the living standard and economic development.

3. How much do the parameters of the HIHD contribute to its development?
    a. GDP per capita is the most important contributor to HIHD, but declines in importance over time.
    b. Education was and is the second largest contributor to the HIHD and its contribution increases moderately.
    c. Life expectancy was and is the lowest contributor. However, its contribution doubled from 1820 to 2019.
    d. Norway did surprisingly well during the 19th century due to long life expectancy rates.
    e. Sweden was clearly inferior to Denmark and Norway in writing skills during the first half of the 19th century, which made their HIHD decline relative to their Scandinavian neighbours.

9.3 Implications

Based on our findings one may ask if parts of our knowledge on relative development for the three Scandinavian countries need reinterpretation. The most surprising finding is perhaps that Norway seems to be above the OECD-level and at the same level as Denmark in the 19th century, and not below. This is much due to Norway's high life expectancy. Sweden seemed to be at the OECD level, and not below.

Even though GDP per capita has increased more than the two social variables, its relative contribution to HIHD is decreasing. Therefore, we believe that it is not as valid an indicator for increased wealth and development as it often is believed to be.

Further, this can be explained through the observation that both education and especially life expectancy's contribution to the HIHD are growing, emphasising their importance.

In conclusion, future research on human and economic development should focus more on social variables.

Literature

Bairoch, P. (1976). “Europe’s Gross National Product 1800-1975”., *Journal of European Economic History 5*, pp. 273-340.

Bennett, Coleman & Co Ltd (2020). “Definition of Human Development Index”. *The Economic Times*. Retrieved from: https://economictimes.indiatimes.com/definition/human-development-index [Downloaded: 01.12.20]

Byberg, L. (2008). *Leseferdighet og skolevesen 1740-1830 Pietister, «potetprester» og et ungt norsk Storting*. Oslo and Akershus University College of Applied Sciences (Oslo Met). Retrieved from: https://oda-hioa.archive.knowledgearc.net/bitstream/handle/10642/888/802941.pdf?sequence=2&isAllowed=y [Downloaded: 25.11.2020]

Corporate Finance Institute (CFI). (2015-2020). What Are Different Theories of Growth? Retrieved from: https://corporatefinanceinstitute.com/resources/knowledge/economics/theories-of-growth/ [Downloaded: 07.09.2020]

Corporate Finance Institute (CFI). (2015-2020). What is the Solow Growth Model? Retrieved from: https://corporatefinanceinstitute.com/resources/knowledge/economics/solow-growth-model/ [Downloaded: 07.09.2020]

Crafts, N. F. R. (1983a). “Gross National Product in Europe 1870-1910: some new estimates”,. *Explorations in Economic History 20*, pp. 387-481.

Crafts, N. F. R. (1983b). “Patterns of development in nineteenth century Europe”,. *Oxford Economic Papers; 46*, pp. 438-458.

Dokka, H. -J. (1988). *En skole gjennom 250 år: Den norske allmueskole, folkeskole, grunnskole 1739-1989*. Oslo: NKS-forlaget

Edvinsson, R. (2013). ‘New annual estimates of Swedish GDP, 1800-2010’. *The Economic History Review; 66*, 4, pp. 1101-1126.

Escosura, L. P. (2014). “World Human Development: 1870-2007”. *The Review of Income and Health; Volume 6, Issue 2*. Retrieved from: https://onlinelibrary.wiley.com/doi/full/10.1111/roiw.12104 [Downloaded: 07.09.2020]

Escosura, L. P. (2015). “World Human Development: 1870-2007”. *The Review of Income and Wealth Volume; 61, Issue 2, June 2015*. Universidad Carlos III and CEPR

Espacio Investiga. (2019). Desarollo Humano – Concepto. Retrieved from: https://espacioinvestiga.org/inicio-hihd/sobre-los-indices-hihd/desarrollo-humano-concepto/?doing_wp_cron=1599471599.0263419151306152343750 [Downloaded: 07.09.2020]

Farlex Financial Dictionary (2012). Geary-Khamis Dollar. *The Free Dictionary By Farlex*. Retrieved from: https://financial-dictionary.thefreedictionary.com/Geary-Khamis+dollars [Downloaded: 08.12.2020]

Flora, P. (1973). "Historical Processes of Social Mobilization: Urbanization and Literacy, 1850-1965". In S. N. Eisenstadt & S. Rokkan (eds), *Building States and Nations Volume 1* (p. 213-258). London: Sage Publications

Folkehelseinstituttet (2014, last edited 2018). «Folkehelse I Norge 1814-2014». *Folkehelserapporten*. Oslo: Folkehelseinstituttet. Retrieved from: https://www.fhi.no/nettpub/hin/folkehelse-i-historien/folkehelse-i-norge-1814---2014/?fbclid=IwAR1m2g2w77mx_YhrKm0ll1OxTH9gdZ2hflb2Kf5jzzdSYw2HFkxOPzxBabU [Downloaded: 15.12.2020]

Grytten, O. H. (2004). "Economic Growth and Purchasing Power Parities in the Nordic Countries, 1830-1910". In S. Heikkinen & J. L. van Zanden (eds), *Explorations in economic growth* (p. 89-104). Amsterdam: aksant.

Grytten, O. H. (2016). «Norges økonomiske vekst under Norges Banks pengeregime». In K. O. Aslaksen & S. E. Amoriza (eds), *Byrde og Berikelse: Sølvskatten 1816-2016* (p. 8-23). Bergen: Universitetsmuseet i Bergen.

Grytten, O. H. (2019). "Public finances, governance control and economic growth: a macroeconomic history approach". *Investment Management and Financial Innovations 2019; Volum 16*. S. 189-202. NHH

Grytten, O. H. (2020), 'Two Centuries of Economic Growth: Norwegian GDP 1816-2020'. *NHH Dept. of Economics Discussion Paper No. 10/2020,* Available at SSRN: https://ssrn.com/abstract=3632902 or http://dx.doi.org/10.2139/ssrn.3632902

Grytten, O. H. 2020. Two Centuries of Economic Growth: Norwegian GDP 1816-2020. Retrieved from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3632902 [Downloaded: 07.09.2020]

Hansen, Svend Aa (1983). *Økonomisk vækst i Danmark 1914-1983*. Copenhagen: Akademisk Forlag.

Haukland, L. (2014). Hans Nielsen Hauge: A Catalyst of Literacy in Norway. Retrieved from: https://nordopen.nord.no/nord-xmlui/bitstream/handle/11250/278853/Haukland.pdf?sequence=5 [Downloaded: 09.10.2020]

Hernæs, K. H. (2011). «Faste priser og kjedingsavvik – hvorfor summerer ikke fastpristallene seg?» *Økonomiske analyser 6* (61-63). Retrieved from: https://www.ssb.no/a/publikasjoner/pdf/oa_201106/hernes.pdf [Downloaded: 07.09.2020]

United Nations Development Programme (2019). Human Development Index (HDI). *Human Development Reports.* Retrieved from: http://hdr.undp.org/en/content/human-development-index-hdi [Downloaded: 07.09.2020]

Johansson, E. (1977). “The History of Literacy in Sweden In comparison with some other countries”. *Educational Reports Umeå no 12*. Umeå University and Umeå School of Education- Sweden. Retrieved from: http://www.diva-portal.org/smash/get/diva2:580289/FULLTEXT01.pdf?fbclid=IwAR1-VUe7V0hxALqQhZbc6tYj6Gx1mXTlS2NiApLiOPuWkVgmf78wWwgnbG4 [Downloaded: 09.10.2020]

Kovacevic, M. (2019). Human Development Index: Concepts and Measurements. *Human Development Report Office*. Retrieved from: https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/2019LINK-Tuesday-Session2-B.pdf [Downloaded: 07.09.2020]

Krantz, O. (2001). Swedish Historical National Accounts 1800-1998: Aggregated Output Series. Umeå: Umeå University.

Krantz, O. & Nilsson, C. (1974). “Relative income levels in the Scandinavian countries”,. *Economy and History 17*, pp. 52-69.

Lindgren, M. (2008, uploaded 2011). Documentation for GDP Per Capita by Purchasing Power Parities for countries and territories. *Gapminder Documentation 001*. Retrieved from: https://www.gapminder.org/documentation/documentation/gapdoc001_v9.pdf [Downloaded: 14.09.2020]

Malthus, T. R. (1799). *Reisedagbok fra Norge 1799*. Published by Cappelen Damm 2005.

Markussen, I. (1985). “Den danske befolknings skrivefaerdighed i 1800-tallet». In V. Skovgaard-Petersen (red), *Da menigmand i Norden lærte at skrive: en sektionsrapport fra 19. nordiske historikerkongress*, Odense: Institutt for dansk skolehistorie

Mitchell, B. R. (1998). “I. Education”. *International Historical Statistics: Europe 1750-1993* (p. 869-901) London: Palgrave Macmillan

Munck, T. (2004). Literacy, Educational Reform and the Use of Print in Eighteenth-century Denmark. Retrieved from: file:///Users/DanielValenGrytten/Downloads/Literacy%20educational%20reform%20and%20the%20use%20of%20print%20in%20eighteenth%20century%20Denmark.pdf [Downloaded: 09.10.2020]

Norges Offisielle Statistikk (1994). Historisk Statistikk fra 1994. Retrieved from: https://www.ssb.no/a/histstat/hs1994.html [Downloaded: 01.12.20]

Oilinfo. (2011). 2011: Tidenes høyeste oljepris. Aldri før har oljeprisen vært så høy som i år. E24. Hentet fra: https://e24.no/olje-og-energi/i/RxAwka/2011-tidenes-hoeyeste-oljepris#:~:text=Aldri%20f%C3%B8r%20har%20oljebprisen%20v%C3%A6rt%20s%C3%A5%20h%C3%B8y%20som%20i%20%C3%A5r.&text=2011%20ligger%20an%20til%20%C3%A5,r%C3%A5olje%20siden%20den%20amerikanske%20borgerkrigen. [Downloaded: 23.11.2020]

O’Neil, A. (2019). Life expectancy in Denmark 1765-2020. Statista. Retrieved from: https://www.statista.com/statistics/1041290/life-expectancy-denmark-all-time/#:~:text=Life%20expectancy%20in%20Denmark%20was,to%2080.7%20years%20in%202020. [Downloaded: 25.11.2020]

Roser, M. (2014, last edited 2019 "Human Development Index (HDI)". *Our World In Data*. Retrieved from: https://ourworldindata.org/human-development-index [Downloaded: 24.08.2020]

Skovgaard-Petersen, V. (1990). "Literacy in the Nordic Countries 1550-1900: a Comparative Study". *Scandinavian Journal of History, Vol 5*. Schiller, B. (Chief Editor) University of Roskilde and University of Gothenburg.

Søbye, E. (2015). «Fødte og døde i Norden». *Folkemengdens Bevegelse 1735-2014: En tabellstudie.* (p. 261-280). Retrieved from: file:///Users/DanielValenGrytten/Downloads/FodteOgDodeINorden.pdf [Downloaded: 25.11.2020]

Thune, T. & Welle-Strand, A. (2009). Analfabetisme i Store Norske Leksikon in snl.no. Retrieved from: https://snl.no/analfabetisme [Downloaded: 01.12.2020]

Tveit, K. (1991). «The Development of Popular Literacy in the Nordic Countries. A Comparative Historical Study". *Scandinavian Journal of Educational Research, Vol 35, No 4*. Retrieved from: file:///Users/DanielValenGrytten/Downloads/The%20Development%20of%20Popular%20Literacy%20in%20the%20Nordic%20Countries.pdf [Downloaded: 09.10.2020]

University of Groningen Growth and Development Centre (2020). Maddison Database 2010. Retrieved from: https://www.rug.nl/ggdc/ [Downloaded: 07.11.2020]

Vannebo, K. I. (1984). *En Nasjon av Skriveføre. Om utviklinga fram mot allmenn skriveferdighet på 1800-tallet*. Oslo: Novus. Retrieved from: https://www.nb.no/nbsok/nb/c5428681ce1c38da9a42880675a5bd07?lang=no#0 [Downloaded: 09.10.2020]

Appendix

A1 Calculated HIHDs and Indices

Below are tables for all the indices for each year which we calculated; the HIHD EF, HIHD VJM, Life expectancy index, Income (GDP per capita) index, Education index EF, Education index VJM, School enrolment rate index, Literacy rate index EF and Literacy rate index VJM.

Table A1.1: Calculated HIHD with Escosura and Flora (EF) based and Vannebo, Johansson and Markussen (VJM) based literacy rates

		HIHD EF		HIHD VJM		
	Sweden	Norway	Denmark	Sweden	Norway	Denmark
1820	0,144	0,191	0,187	0,105	0,139	0,144
1821	0,138	0,182	0,170	0,101	0,133	0,131
1822	0,156	0,188	0,190	0,114	0,138	0,146
1823	0,165	0,199	0,202	0,121	0,146	0,156
1824	0,165	0,196	0,195	0,122	0,144	0,151
1825	0,166	0,202	0,189	0,122	0,149	0,146
1826	0,158	0,196	0,177	0,117	0,145	0,137
1827	0,155	0,199	0,182	0,114	0,147	0,141
1828	0,139	0,193	0,161	0,103	0,143	0,125
1829	0,133	0,194	0,127	0,099	0,144	0,098
1830	0,152	0,192	0,147	0,113	0,143	0,114
1831	0,144	0,192	0,112	0,108	0,143	0,088
1832	0,151	0,200	0,138	0,112	0,149	0,108
1833	0,159	0,191	0,159	0,119	0,143	0,125
1834	0,145	0,180	0,162	0,109	0,135	0,127
1835	0,177	0,197	0,171	0,133	0,148	0,134
1836	0,171	0,198	0,179	0,128	0,149	0,140
1837	0,150	0,189	0,187	0,114	0,143	0,147
1838	0,152	0,185	0,194	0,115	0,140	0,153
1839	0,152	0,186	0,189	0,116	0,142	0,150
1840	0,169	0,197	0,186	0,130	0,152	0,149
1841	0,174	0,215	0,193	0,135	0,166	0,155
1842	0,164	0,211	0,193	0,128	0,163	0,155
1843	0,166	0,210	0,200	0,130	0,164	0,162
1844	0,172	0,216	0,202	0,136	0,169	0,164
1845	0,180	0,216	0,199	0,143	0,171	0,163
1846	0,163	0,209	0,187	0,131	0,166	0,154
1847	0,156	0,196	0,187	0,127	0,157	0,155
1848	0,177	0,196	0,189	0,144	0,158	0,158
1849	0,176	0,210	0,184	0,145	0,170	0,155
1850	0,177	0,217	0,204	0,146	0,177	0,172

1851	0,173	0,219	0,207	0,144	0,179	0,176
1852	0,164	0,214	0,201	0,137	0,177	0,173
1853	0,159	0,214	0,180	0,133	0,177	0,155
1854	0,177	0,230	0,208	0,150	0,192	0,181
1855	0,173	0,226	0,216	0,147	0,189	0,189
1856	0,169	0,225	0,217	0,145	0,189	0,191
1857	0,137	0,224	0,198	0,117	0,189	0,176
1858	0,171	0,231	0,186	0,147	0,196	0,166
1859	0,182	0,224	0,208	0,157	0,191	0,186
1860	0,198	0,225	0,210	0,172	0,193	0,190
1861	0,193	0,208	0,221	0,168	0,179	0,200
1862	0,175	0,204	0,222	0,152	0,176	0,202
1863	0,188	0,214	0,223	0,163	0,185	0,204
1864	0,187	0,223	0,190	0,162	0,193	0,174
1865	0,194	0,230	0,189	0,169	0,200	0,174
1866	0,193	0,229	0,204	0,168	0,200	0,189
1867	0,201	0,222	0,214	0,176	0,194	0,198
1868	0,188	0,218	0,217	0,165	0,192	0,203
1869	0,183	0,228	0,221	0,161	0,201	0,207
1870	0,206	0,237	0,223	0,183	0,210	0,210
1871	0,225	0,234	0,224	0,200	0,208	0,212
1872	0,231	0,237	0,232	0,208	0,212	0,222
1873	0,227	0,237	0,233	0,205	0,213	0,224
1874	0,209	0,229	0,228	0,190	0,207	0,220
1875	0,212	0,230	0,221	0,194	0,208	0,214
1876	0,215	0,228	0,228	0,198	0,208	0,221
1877	0,220	0,240	0,234	0,204	0,220	0,227
1878	0,223	0,249	0,236	0,207	0,229	0,229
1879	0,235	0,256	0,231	0,219	0,237	0,225
1880	0,230	0,252	0,226	0,215	0,235	0,220
1881	0,235	0,246	0,243	0,220	0,230	0,236
1882	0,235	0,234	0,237	0,222	0,220	0,230
1883	0,239	0,245	0,247	0,227	0,232	0,240
1884	0,240	0,250	0,248	0,229	0,238	0,241
1885	0,239	0,252	0,254	0,230	0,240	0,246
1886	0,247	0,255	0,253	0,238	0,245	0,245
1887	0,250	0,256	0,254	0,242	0,247	0,245
1888	0,255	0,252	0,246	0,248	0,244	0,237
1889	0,255	0,248	0,252	0,249	0,241	0,243
1890	0,248	0,247	0,253	0,243	0,242	0,243
1891	0,251	0,253	0,251	0,247	0,250	0,242
1892	0,251	0,254	0,255	0,247	0,252	0,246
1893	0,257	0,263	0,255	0,253	0,263	0,246

1894	0,261	0,262	0,267	0,257	0,263	0,258
1895	0,271	0,274	0,276	0,268	0,277	0,267
1896	0,270	0,280	0,287	0,268	0,284	0,279
1897	0,275	0,282	0,283	0,274	0,286	0,275
1898	0,279	0,284	0,290	0,280	0,288	0,282
1899	0,264	0,274	0,279	0,266	0,278	0,273
1900	0,271	0,284	0,287	0,274	0,288	0,280
1901	0,275	0,291	0,291	0,279	0,296	0,286
1902	0,285	0,301	0,302	0,289	0,307	0,297
1903	0,289	0,296	0,304	0,295	0,302	0,300
1904	0,293	0,303	0,310	0,299	0,310	0,306
1905	0,290	0,300	0,304	0,297	0,307	0,301
1906	0,304	0,311	0,315	0,312	0,320	0,313
1907	0,309	0,312	0,314	0,317	0,320	0,313
1908	0,307	0,313	0,309	0,315	0,321	0,310
1909	0,318	0,321	0,323	0,326	0,329	0,324
1910	0,318	0,327	0,327	0,326	0,335	0,330
1911	0,322	0,330	0,323	0,331	0,340	0,328
1912	0,323	0,331	0,328	0,334	0,342	0,335
1913	0,331	0,338	0,333	0,344	0,351	0,342
1914	0,327	0,335	0,333	0,341	0,350	0,344
1915	0,321	0,338	0,330	0,336	0,354	0,344
1916	0,327	0,334	0,323	0,342	0,350	0,337
1917	0,324	0,333	0,322	0,339	0,349	0,336
1918	0,278	0,293	0,315	0,291	0,307	0,329
1919	0,310	0,330	0,322	0,324	0,346	0,335
1920	0,321	0,342	0,326	0,335	0,358	0,339
1921	0,327	0,352	0,347	0,342	0,368	0,360
1922	0,329	0,349	0,344	0,345	0,365	0,357
1923	0,339	0,356	0,351	0,355	0,372	0,363
1924	0,335	0,356	0,351	0,350	0,373	0,363
1925	0,336	0,357	0,355	0,352	0,374	0,366
1926	0,339	0,361	0,356	0,355	0,378	0,366
1927	0,334	0,360	0,355	0,350	0,377	0,364
1928	0,338	0,365	0,361	0,354	0,381	0,369
1929	0,340	0,362	0,365	0,356	0,378	0,371
1930	0,347	0,373	0,369	0,363	0,390	0,375
1931	0,344	0,371	0,366	0,360	0,388	0,371
1932	0,350	0,376	0,372	0,366	0,393	0,378
1933	0,356	0,383	0,379	0,373	0,400	0,385
1934	0,359	0,390	0,382	0,375	0,407	0,388
1935	0,360	0,391	0,374	0,375	0,407	0,380
1936	0,361	0,395	0,378	0,375	0,410	0,383

1937	0,362	0,401	0,380	0,374	0,415	0,386
1938	0,368	0,410	0,386	0,380	0,424	0,392
1939	0,377	0,413	0,393	0,389	0,426	0,399
1940	0,378	0,400	0,391	0,390	0,412	0,397
1941	0,382	0,400	0,386	0,393	0,411	0,393
1942	0,396	0,397	0,394	0,407	0,408	0,401
1943	0,399	0,399	0,400	0,409	0,409	0,407
1944	0,396	0,395	0,398	0,405	0,404	0,404
1945	0,402	0,413	0,394	0,411	0,423	0,400
1946	0,415	0,425	0,406	0,424	0,435	0,412
1947	0,419	0,433	0,416	0,428	0,442	0,423
1948	0,430	0,443	0,428	0,439	0,451	0,435
1949	0,434	0,446	0,432	0,442	0,454	0,438
1950	0,441	0,448	0,436	0,448	0,455	0,443
1951	0,448	0,459	0,445	0,455	0,466	0,451
1952	0,455	0,464	0,447	0,462	0,471	0,453
1953	0,460	0,471	0,455	0,467	0,479	0,461
1954	0,470	0,476	0,460	0,477	0,484	0,466
1955	0,477	0,481	0,469	0,485	0,488	0,474
1956	0,480	0,486	0,471	0,487	0,492	0,475
1957	0,480	0,489	0,472	0,486	0,495	0,477
1958	0,488	0,491	0,477	0,493	0,496	0,481
1959	0,493	0,497	0,481	0,497	0,501	0,484
1960	0,493	0,502	0,481	0,496	0,505	0,484
1961	0,497	0,503	0,485	0,501	0,508	0,488
1962	0,495	0,503	0,486	0,501	0,508	0,489
1963	0,497	0,501	0,487	0,503	0,507	0,490
1964	0,499	0,506	0,491	0,506	0,513	0,493
1965	0,500	0,509	0,491	0,508	0,517	0,493
1966	0,508	0,518	0,500	0,515	0,524	0,501
1967	0,516	0,526	0,512	0,521	0,531	0,514
1968	0,523	0,531	0,524	0,526	0,535	0,524
1969	0,532	0,536	0,535	0,534	0,538	0,536
1970	0,547	0,548	0,547	0,547	0,547	0,547
1971	0,549	0,552	0,549	0,549	0,552	0,549
1972	0,552	0,556	0,552	0,552	0,556	0,552
1973	0,557	0,560	0,555	0,557	0,560	0,555
1974	0,560	0,564	0,556	0,560	0,564	0,556
1975	0,562	0,568	0,557	0,563	0,568	0,557
1976	0,567	0,573	0,563	0,567	0,573	0,563
1977	0,571	0,579	0,571	0,571	0,579	0,570
1978	0,576	0,583	0,576	0,576	0,583	0,576
1979	0,581	0,587	0,581	0,581	0,587	0,581

1980	0,588	0,593	0,585	0,588	0,593	0,585
1981	0,592	0,596	0,586	0,592	0,596	0,586
1982	0,595	0,599	0,589	0,595	0,599	0,589
1983	0,599	0,602	0,591	0,599	0,602	0,591
1984	0,603	0,607	0,593	0,603	0,607	0,593
1985	0,604	0,609	0,596	0,604	0,609	0,595
1986	0,606	0,611	0,600	0,606	0,611	0,600
1987	0,608	0,612	0,601	0,608	0,612	0,601
1988	0,610	0,615	0,602	0,610	0,614	0,602
1989	0,614	0,618	0,604	0,614	0,618	0,604
1990	0,616	0,621	0,605	0,616	0,621	0,605
1991	0,621	0,632	0,612	0,621	0,632	0,612
1992	0,633	0,641	0,616	0,633	0,641	0,616
1993	0,641	0,652	0,619	0,641	0,652	0,619
1994	0,655	0,665	0,623	0,655	0,665	0,623
1995	0,668	0,678	0,629	0,668	0,678	0,629
1996	0,683	0,689	0,640	0,683	0,689	0,640
1997	0,702	0,700	0,653	0,702	0,700	0,653
1998	0,707	0,709	0,667	0,707	0,709	0,667
1999	0,718	0,720	0,674	0,718	0,720	0,674
2000	0,732	0,731	0,696	0,732	0,731	0,696
2001	0,728	0,729	0,706	0,728	0,729	0,706
2002	0,734	0,735	0,715	0,733	0,735	0,715
2003	0,747	0,752	0,730	0,747	0,752	0,730
2004	0,764	0,779	0,752	0,764	0,779	0,752
2005	0,764	0,775	0,746	0,764	0,775	0,746
2006	0,773	0,787	0,739	0,773	0,787	0,739
2007	0,778	0,791	0,741	0,778	0,791	0,741
2008	0,779	0,792	0,745	0,779	0,792	0,745
2009	0,780	0,793	0,747	0,780	0,793	0,747
2010	0,798	0,803	0,760	0,798	0,803	0,760
2011	0,804	0,803	0,773	0,804	0,804	0,773
2012	0,802	0,813	0,772	0,802	0,813	0,772
2013	0,813	0,823	0,786	0,813	0,823	0,786
2014	0,812	0,826	0,785	0,812	0,826	0,785
2015	0,822	0,843	0,795	0,822	0,843	0,795
2016	0,835	0,854	0,802	0,835	0,854	0,802
2017	0,839	0,855	0,803	0,840	0,855	0,803
2018	0,845	0,860	0,806	0,845	0,860	0,806
2019	0,852	0,866	0,811	0,852	0,866	0,811

Table A1.2: Calculated Life expectancy index and income index:

		Life Expectancy Index			Income Index	
	Sweden	Norway	Denmark	Sweden	Norway	Denmark
1820	0,072	0,111	0,088	0,323	0,349	0,396
1821	0,060	0,097	0,065	0,331	0,342	0,402
1822	0,086	0,106	0,089	0,339	0,347	0,403
1823	0,100	0,123	0,108	0,340	0,350	0,400
1824	0,099	0,116	0,096	0,345	0,356	0,403
1825	0,101	0,126	0,088	0,340	0,354	0,402
1826	0,088	0,116	0,072	0,338	0,355	0,402
1827	0,085	0,121	0,076	0,325	0,353	0,405
1828	0,058	0,107	0,053	0,338	0,360	0,406
1829	0,050	0,107	0,026	0,344	0,363	0,402
1830	0,076	0,104	0,040	0,341	0,362	0,403
1831	0,065	0,103	0,018	0,340	0,361	0,402
1832	0,075	0,116	0,033	0,332	0,364	0,406
1833	0,084	0,098	0,050	0,345	0,371	0,404
1834	0,062	0,081	0,052	0,350	0,375	0,411
1835	0,112	0,106	0,061	0,348	0,374	0,409
1836	0,100	0,108	0,070	0,350	0,371	0,407
1837	0,068	0,094	0,079	0,347	0,371	0,410
1838	0,070	0,087	0,088	0,342	0,373	0,410
1839	0,070	0,087	0,081	0,345	0,376	0,411
1840	0,093	0,103	0,076	0,351	0,382	0,415
1841	0,100	0,128	0,085	0,350	0,386	0,413
1842	0,086	0,121	0,084	0,341	0,386	0,412
1843	0,086	0,121	0,092	0,347	0,382	0,420
1844	0,093	0,130	0,093	0,355	0,384	0,425
1845	0,105	0,132	0,089	0,360	0,387	0,428
1846	0,082	0,118	0,073	0,349	0,391	0,430
1847	0,071	0,098	0,073	0,352	0,387	0,428
1848	0,100	0,099	0,074	0,359	0,383	0,434
1849	0,096	0,118	0,068	0,369	0,392	0,442

1850	0,097	0,128	0,090	0,369	0,398	0,449
1851	0,091	0,130	0,096	0,366	0,402	0,439
1852	0,078	0,121	0,088	0,362	0,405	0,443
1853	0,070	0,118	0,063	0,364	0,413	0,442
1854	0,096	0,143	0,097	0,366	0,420	0,441
1855	0,088	0,135	0,106	0,374	0,424	0,456
1856	0,082	0,134	0,110	0,374	0,420	0,444
1857	0,043	0,133	0,084	0,378	0,413	0,445
1858	0,081	0,143	0,070	0,384	0,421	0,442
1859	0,095	0,131	0,096	0,394	0,420	0,450
1860	0,121	0,132	0,100	0,398	0,423	0,447
1861	0,112	0,104	0,116	0,396	0,421	0,447
1862	0,085	0,097	0,116	0,385	0,426	0,450
1863	0,101	0,110	0,115	0,395	0,430	0,458
1864	0,098	0,123	0,071	0,399	0,431	0,455
1865	0,101	0,135	0,069	0,403	0,437	0,459
1866	0,097	0,131	0,087	0,400	0,440	0,457
1867	0,106	0,117	0,099	0,403	0,444	0,456
1868	0,088	0,113	0,103	0,378	0,437	0,457
1869	0,076	0,126	0,106	0,397	0,443	0,464
1870	0,099	0,138	0,106	0,423	0,454	0,470
1871	0,125	0,129	0,106	0,427	0,457	0,469
1872	0,132	0,132	0,115	0,433	0,462	0,476
1873	0,123	0,129	0,115	0,437	0,468	0,474
1874	0,095	0,116	0,106	0,433	0,464	0,478
1875	0,097	0,116	0,096	0,436	0,464	0,479
1876	0,098	0,110	0,104	0,445	0,472	0,481
1877	0,106	0,130	0,114	0,442	0,467	0,475
1878	0,110	0,144	0,115	0,438	0,463	0,480
1879	0,124	0,155	0,107	0,448	0,469	0,483
1880	0,116	0,145	0,098	0,442	0,475	0,486
1881	0,121	0,135	0,120	0,445	0,470	0,487
1882	0,122	0,114	0,110	0,442	0,476	0,491
1883	0,125	0,129	0,122	0,453	0,480	0,496
1884	0,126	0,137	0,122	0,453	0,477	0,495
1885	0,124	0,139	0,129	0,456	0,476	0,495
1886	0,136	0,144	0,125	0,455	0,478	0,500
1887	0,142	0,144	0,123	0,452	0,479	0,504
1888	0,149	0,134	0,110	0,460	0,486	0,504
1889	0,148	0,125	0,117	0,457	0,491	0,505
1890	0,135	0,122	0,113	0,464	0,495	0,513
1891	0,139	0,130	0,110	0,461	0,495	0,516
1892	0,136	0,129	0,115	0,469	0,496	0,519

1893	0,141	0,141	0,112	0,475	0,501	0,521
1894	0,147	0,136	0,127	0,477	0,506	0,523
1895	0,162	0,152	0,138	0,482	0,512	0,530
1896	0,157	0,160	0,153	0,487	0,515	0,535
1897	0,162	0,159	0,145	0,493	0,521	0,536
1898	0,167	0,161	0,154	0,498	0,522	0,537
1899	0,138	0,143	0,136	0,505	0,521	0,542
1900	0,148	0,157	0,145	0,503	0,521	0,546
1901	0,153	0,165	0,151	0,505	0,521	0,551
1902	0,167	0,181	0,167	0,504	0,522	0,553
1903	0,170	0,169	0,167	0,512	0,522	0,561
1904	0,172	0,178	0,175	0,517	0,523	0,563
1905	0,165	0,170	0,164	0,516	0,524	0,565
1906	0,183	0,185	0,182	0,528	0,533	0,568
1907	0,186	0,181	0,178	0,538	0,536	0,572
1908	0,181	0,180	0,168	0,534	0,540	0,575
1909	0,199	0,190	0,189	0,533	0,542	0,580
1910	0,193	0,194	0,195	0,541	0,549	0,583
1911	0,195	0,195	0,186	0,545	0,554	0,588
1912	0,193	0,192	0,195	0,550	0,558	0,585
1913	0,201	0,197	0,203	0,559	0,566	0,588
1914	0,197	0,193	0,199	0,557	0,567	0,595
1915	0,188	0,196	0,198	0,561	0,572	0,580
1916	0,197	0,188	0,185	0,570	0,579	0,584
1917	0,203	0,192	0,188	0,548	0,562	0,571
1918	0,130	0,133	0,179	0,543	0,553	0,563
1919	0,182	0,184	0,185	0,545	0,573	0,579
1920	0,202	0,202	0,190	0,551	0,580	0,584
1921	0,224	0,229	0,231	0,533	0,561	0,575
1922	0,224	0,221	0,219	0,550	0,571	0,588
1923	0,245	0,231	0,225	0,554	0,580	0,602
1924	0,234	0,234	0,225	0,562	0,579	0,599
1925	0,240	0,239	0,233	0,562	0,576	0,593
1926	0,242	0,247	0,230	0,572	0,575	0,599
1927	0,230	0,242	0,225	0,577	0,583	0,600
1928	0,237	0,248	0,232	0,580	0,589	0,603
1929	0,237	0,238	0,233	0,592	0,600	0,612
1930	0,247	0,256	0,236	0,597	0,606	0,620
1931	0,241	0,257	0,232	0,595	0,592	0,612
1932	0,255	0,262	0,241	0,588	0,596	0,617
1933	0,266	0,273	0,251	0,593	0,600	0,624
1934	0,268	0,282	0,257	0,603	0,603	0,628
1935	0,266	0,277	0,243	0,612	0,610	0,631

1936	0,263	0,277	0,249	0,621	0,617	0,634
1937	0,263	0,279	0,255	0,625	0,625	0,638
1938	0,275	0,293	0,267	0,631	0,627	0,641
1939	0,286	0,297	0,277	0,644	0,633	0,648
1940	0,290	0,278	0,283	0,629	0,616	0,622
1941	0,294	0,276	0,279	0,628	0,619	0,605
1942	0,322	0,275	0,294	0,629	0,611	0,607
1943	0,318	0,280	0,298	0,637	0,607	0,623
1944	0,304	0,276	0,284	0,640	0,597	0,637
1945	0,312	0,308	0,280	0,641	0,614	0,623
1946	0,330	0,328	0,295	0,656	0,631	0,645
1947	0,329	0,336	0,314	0,664	0,649	0,653
1948	0,350	0,355	0,338	0,665	0,658	0,656
1949	0,351	0,361	0,338	0,667	0,661	0,665
1950	0,357	0,363	0,341	0,677	0,667	0,677
1951	0,361	0,380	0,351	0,681	0,673	0,681
1952	0,370	0,383	0,349	0,682	0,677	0,683
1953	0,371	0,392	0,355	0,685	0,684	0,693
1954	0,379	0,394	0,358	0,694	0,691	0,693
1955	0,384	0,398	0,369	0,698	0,692	0,693
1956	0,385	0,399	0,371	0,702	0,699	0,694
1957	0,382	0,398	0,367	0,704	0,703	0,708
1958	0,395	0,398	0,374	0,707	0,701	0,711
1959	0,399	0,400	0,374	0,714	0,708	0,723
1960	0,393	0,401	0,374	0,720	0,716	0,723
1961	0,402	0,401	0,379	0,729	0,724	0,733
1962	0,399	0,398	0,376	0,736	0,729	0,742
1963	0,403	0,391	0,378	0,743	0,734	0,743
1964	0,407	0,401	0,380	0,754	0,741	0,757
1965	0,410	0,403	0,377	0,758	0,748	0,764
1966	0,416	0,410	0,379	0,760	0,753	0,768
1967	0,416	0,411	0,388	0,764	0,762	0,773
1968	0,413	0,408	0,392	0,769	0,765	0,779
1969	0,416	0,402	0,394	0,776	0,771	0,790
1970	0,429	0,411	0,396	0,784	0,773	0,795
1971	0,431	0,414	0,399	0,784	0,781	0,799
1972	0,434	0,419	0,402	0,787	0,788	0,805
1973	0,438	0,422	0,406	0,794	0,795	0,810
1974	0,440	0,427	0,410	0,798	0,800	0,808
1975	0,441	0,429	0,413	0,802	0,807	0,805
1976	0,444	0,434	0,414	0,803	0,815	0,814
1977	0,449	0,440	0,420	0,800	0,821	0,816
1978	0,453	0,444	0,420	0,802	0,827	0,819

1979	0,455	0,446	0,419	0,808	0,833	0,825
1980	0,462	0,451	0,419	0,810	0,840	0,824
1981	0,471	0,456	0,420	0,811	0,842	0,823
1982	0,478	0,459	0,423	0,813	0,842	0,829
1983	0,485	0,461	0,423	0,816	0,847	0,833
1984	0,491	0,463	0,425	0,822	0,857	0,840
1985	0,492	0,462	0,426	0,825	0,865	0,846
1986	0,496	0,464	0,429	0,829	0,871	0,859
1987	0,498	0,465	0,432	0,834	0,871	0,854
1988	0,501	0,470	0,434	0,837	0,871	0,854
1989	0,511	0,477	0,435	0,841	0,872	0,855
1990	0,515	0,482	0,438	0,841	0,875	0,857
1991	0,516	0,492	0,445	0,838	0,879	0,859
1992	0,530	0,496	0,447	0,835	0,884	0,862
1993	0,537	0,504	0,447	0,830	0,888	0,861
1994	0,550	0,512	0,446	0,836	0,895	0,869
1995	0,559	0,520	0,449	0,841	0,900	0,873
1996	0,567	0,526	0,457	0,843	0,908	0,877
1997	0,578	0,534	0,468	0,848	0,915	0,881
1998	0,582	0,536	0,480	0,855	0,918	0,884
1999	0,586	0,542	0,473	0,862	0,920	0,888
2000	0,595	0,545	0,493	0,869	0,924	0,894
2001	0,600	0,556	0,497	0,871	0,927	0,895
2002	0,609	0,564	0,498	0,874	0,928	0,895
2003	0,620	0,584	0,507	0,877	0,929	0,895
2004	0,619	0,598	0,519	0,883	0,934	0,899
2005	0,640	0,613	0,536	0,887	0,937	0,902
2006	0,648	0,628	0,537	0,894	0,940	0,908
2007	0,654	0,635	0,539	0,898	0,943	0,909
2008	0,663	0,642	0,554	0,896	0,942	0,907
2009	0,671	0,648	0,563	0,888	0,937	0,898
2010	0,695	0,656	0,574	0,896	0,936	0,900
2011	0,703	0,651	0,598	0,900	0,936	0,902
2012	0,716	0,692	0,614	0,898	0,938	0,901
2013	0,725	0,694	0,627	0,898	0,937	0,902
2014	0,741	0,724	0,644	0,901	0,939	0,904
2015	0,751	0,755	0,654	0,906	0,940	0,907
2016	0,768	0,763	0,650	0,908	0,941	0,910
2017	0,776	0,761	0,647	0,910	0,943	0,913
2018	0,790	0,772	0,654	0,912	0,944	0,916
2019	0,805	0,785	0,660	0,912	0,945	0,919

Table A1.3: Calculated Education Indices with Escosura and Flora (EF) based and Vannebo, Johansson and Markussen (VJM) based literacy rates

		Education Index EF			Education Index VJM	
	Sweden	Norway	Denmark	Sweden	Norway	Denmark
1820	0,130	0,181	0,188	0,051	0,070	0,086
1821	0,131	0,181	0,189	0,051	0,070	0,086
1822	0,131	0,182	0,190	0,052	0,071	0,087
1823	0,132	0,183	0,190	0,052	0,072	0,088
1824	0,133	0,183	0,191	0,053	0,073	0,088
1825	0,133	0,184	0,192	0,053	0,073	0,089
1826	0,134	0,185	0,193	0,054	0,074	0,090
1827	0,134	0,186	0,194	0,054	0,075	0,090
1828	0,135	0,186	0,195	0,055	0,076	0,091
1829	0,136	0,187	0,195	0,055	0,076	0,092
1830	0,136	0,188	0,196	0,056	0,077	0,093
1831	0,137	0,189	0,197	0,056	0,078	0,093
1832	0,138	0,190	0,198	0,057	0,079	0,094
1833	0,139	0,190	0,199	0,058	0,080	0,095
1834	0,140	0,191	0,200	0,059	0,080	0,096
1835	0,142	0,192	0,201	0,060	0,081	0,096
1836	0,143	0,193	0,202	0,061	0,082	0,097
1837	0,144	0,194	0,203	0,062	0,083	0,098
1838	0,145	0,194	0,203	0,064	0,085	0,100
1839	0,147	0,195	0,204	0,066	0,087	0,102
1840	0,148	0,196	0,205	0,067	0,089	0,104
1841	0,150	0,200	0,206	0,070	0,092	0,106
1842	0,152	0,200	0,206	0,072	0,094	0,108
1843	0,152	0,201	0,207	0,074	0,096	0,110
1844	0,152	0,201	0,207	0,076	0,097	0,112
1845	0,153	0,198	0,208	0,078	0,098	0,114
1846	0,153	0,198	0,208	0,080	0,100	0,116
1847	0,154	0,199	0,209	0,081	0,102	0,119
1848	0,154	0,199	0,209	0,083	0,104	0,121
1849	0,154	0,200	0,210	0,085	0,106	0,124
1850	0,155	0,200	0,210	0,087	0,108	0,127
1851	0,155	0,201	0,210	0,089	0,110	0,129
1852	0,156	0,201	0,210	0,091	0,113	0,132
1853	0,157	0,201	0,209	0,093	0,115	0,135

1854	0,157	0,202	0,209	0,095	0,117	0,138
1855	0,158	0,202	0,209	0,097	0,119	0,140
1856	0,158	0,203	0,209	0,098	0,121	0,142
1857	0,159	0,203	0,208	0,100	0,123	0,145
1858	0,160	0,204	0,208	0,102	0,125	0,148
1859	0,161	0,205	0,208	0,103	0,127	0,150
1860	0,161	0,205	0,208	0,105	0,129	0,153
1861	0,163	0,206	0,209	0,106	0,130	0,156
1862	0,164	0,206	0,210	0,107	0,132	0,158
1863	0,166	0,207	0,211	0,109	0,134	0,161
1864	0,167	0,207	0,212	0,110	0,135	0,163
1865	0,179	0,208	0,213	0,118	0,137	0,166
1866	0,184	0,209	0,215	0,122	0,139	0,170
1867	0,190	0,210	0,217	0,128	0,141	0,173
1868	0,197	0,210	0,218	0,134	0,143	0,177
1869	0,204	0,212	0,220	0,140	0,145	0,180
1870	0,210	0,214	0,223	0,146	0,148	0,186
1871	0,213	0,216	0,225	0,151	0,152	0,192
1872	0,216	0,219	0,228	0,156	0,156	0,199
1873	0,219	0,221	0,231	0,162	0,160	0,207
1874	0,222	0,224	0,234	0,168	0,164	0,210
1875	0,225	0,226	0,235	0,173	0,168	0,213
1876	0,228	0,227	0,236	0,177	0,172	0,215
1877	0,229	0,228	0,237	0,181	0,176	0,216
1878	0,231	0,230	0,238	0,184	0,180	0,218
1879	0,233	0,231	0,239	0,188	0,184	0,220
1880	0,237	0,232	0,240	0,194	0,189	0,222
1881	0,239	0,234	0,243	0,198	0,192	0,224
1882	0,241	0,236	0,247	0,203	0,197	0,226
1883	0,242	0,238	0,250	0,207	0,201	0,229
1884	0,242	0,239	0,254	0,212	0,205	0,231
1885	0,242	0,241	0,257	0,216	0,210	0,234
1886	0,243	0,243	0,261	0,219	0,214	0,236
1887	0,243	0,244	0,264	0,221	0,219	0,238
1888	0,243	0,246	0,268	0,224	0,224	0,241
1889	0,244	0,247	0,272	0,227	0,229	0,243
1890	0,245	0,250	0,277	0,231	0,235	0,246
1891	0,247	0,252	0,279	0,234	0,241	0,248
1892	0,250	0,255	0,280	0,237	0,249	0,251
1893	0,252	0,258	0,282	0,241	0,256	0,254
1894	0,253	0,261	0,284	0,243	0,265	0,257
1895	0,254	0,264	0,287	0,246	0,275	0,260
1896	0,257	0,267	0,289	0,251	0,278	0,264

1897	0,259	0,270	0,291	0,257	0,282	0,267
1898	0,262	0,273	0,293	0,263	0,285	0,270
1899	0,264	0,276	0,295	0,269	0,289	0,274
1900	0,266	0,280	0,297	0,276	0,293	0,278
1901	0,270	0,284	0,298	0,281	0,299	0,281
1902	0,273	0,289	0,299	0,287	0,306	0,284
1903	0,277	0,293	0,300	0,294	0,312	0,287
1904	0,281	0,298	0,301	0,301	0,319	0,290
1905	0,285	0,302	0,302	0,308	0,327	0,294
1906	0,290	0,307	0,303	0,313	0,332	0,298
1907	0,294	0,312	0,304	0,317	0,337	0,302
1908	0,298	0,317	0,305	0,322	0,342	0,306
1909	0,303	0,323	0,306	0,327	0,348	0,311
1910	0,308	0,328	0,307	0,332	0,354	0,316
1911	0,313	0,334	0,308	0,341	0,364	0,322
1912	0,318	0,340	0,309	0,350	0,374	0,329
1913	0,323	0,346	0,311	0,361	0,386	0,336
1914	0,319	0,345	0,311	0,362	0,391	0,344
1915	0,315	0,344	0,311	0,361	0,395	0,354
1916	0,311	0,344	0,311	0,356	0,394	0,354
1917	0,307	0,343	0,311	0,352	0,393	0,353
1918	0,303	0,342	0,312	0,347	0,392	0,352
1919	0,299	0,342	0,312	0,343	0,392	0,352
1920	0,296	0,341	0,312	0,339	0,391	0,351
1921	0,293	0,339	0,314	0,336	0,389	0,352
1922	0,290	0,337	0,317	0,332	0,387	0,353
1923	0,287	0,335	0,319	0,329	0,384	0,354
1924	0,285	0,334	0,321	0,326	0,382	0,355
1925	0,282	0,332	0,324	0,323	0,380	0,357
1926	0,282	0,332	0,328	0,323	0,380	0,357
1927	0,281	0,331	0,332	0,323	0,380	0,357
1928	0,281	0,331	0,337	0,322	0,380	0,358
1929	0,281	0,331	0,342	0,322	0,380	0,358
1930	0,282	0,334	0,343	0,324	0,383	0,359
1931	0,284	0,337	0,344	0,325	0,386	0,361
1932	0,286	0,339	0,346	0,327	0,389	0,362
1933	0,287	0,342	0,347	0,329	0,392	0,363
1934	0,287	0,348	0,345	0,327	0,396	0,361
1935	0,287	0,354	0,343	0,324	0,400	0,359
1936	0,287	0,361	0,341	0,322	0,405	0,357
1937	0,287	0,368	0,338	0,319	0,409	0,354
1938	0,287	0,375	0,336	0,317	0,413	0,352
1939	0,292	0,375	0,338	0,321	0,411	0,354

1940	0,297	0,374	0,340	0,325	0,409	0,356
1941	0,302	0,374	0,342	0,329	0,407	0,358
1942	0,308	0,373	0,344	0,334	0,405	0,360
1943	0,313	0,373	0,345	0,338	0,403	0,362
1944	0,319	0,373	0,347	0,343	0,401	0,364
1945	0,324	0,372	0,349	0,348	0,399	0,366
1946	0,330	0,372	0,351	0,352	0,397	0,368
1947	0,336	0,372	0,353	0,357	0,395	0,370
1948	0,343	0,372	0,355	0,362	0,393	0,372
1949	0,349	0,372	0,357	0,368	0,391	0,374
1950	0,356	0,372	0,359	0,373	0,389	0,376
1951	0,365	0,378	0,367	0,382	0,396	0,383
1952	0,375	0,384	0,375	0,392	0,402	0,391
1953	0,384	0,391	0,384	0,403	0,409	0,399
1954	0,395	0,397	0,393	0,413	0,416	0,408
1955	0,406	0,404	0,403	0,425	0,423	0,417
1956	0,409	0,411	0,405	0,426	0,428	0,417
1957	0,412	0,418	0,406	0,427	0,433	0,418
1958	0,416	0,425	0,408	0,429	0,439	0,419
1959	0,419	0,433	0,410	0,430	0,444	0,420
1960	0,423	0,440	0,412	0,432	0,449	0,421
1961	0,418	0,439	0,412	0,429	0,451	0,420
1962	0,414	0,439	0,412	0,427	0,452	0,419
1963	0,410	0,438	0,412	0,425	0,454	0,418
1964	0,406	0,437	0,412	0,423	0,455	0,417
1965	0,401	0,436	0,412	0,420	0,457	0,416
1966	0,416	0,450	0,429	0,432	0,468	0,433
1967	0,432	0,465	0,449	0,445	0,479	0,452
1968	0,449	0,481	0,470	0,458	0,491	0,472
1969	0,467	0,498	0,493	0,472	0,503	0,494
1970	0,487	0,517	0,519	0,487	0,517	0,519
1971	0,490	0,519	0,519	0,490	0,519	0,519
1972	0,493	0,522	0,519	0,493	0,522	0,519
1973	0,497	0,524	0,519	0,497	0,524	0,519
1974	0,500	0,527	0,519	0,500	0,527	0,519
1975	0,503	0,529	0,519	0,503	0,529	0,519
1976	0,510	0,533	0,530	0,510	0,533	0,530
1977	0,518	0,537	0,542	0,518	0,537	0,542
1978	0,526	0,541	0,554	0,526	0,541	0,554
1979	0,534	0,545	0,567	0,534	0,545	0,567
1980	0,543	0,550	0,582	0,543	0,550	0,582
1981	0,543	0,553	0,582	0,543	0,553	0,582
1982	0,543	0,556	0,583	0,543	0,556	0,583

1983	0,543	0,559	0,584	0,543	0,559	0,584
1984	0,543	0,562	0,585	0,543	0,562	0,585
1985	0,543	0,565	0,586	0,543	0,565	0,586
1986	0,542	0,566	0,587	0,542	0,566	0,587
1987	0,541	0,566	0,588	0,541	0,566	0,588
1988	0,540	0,567	0,589	0,540	0,567	0,589
1989	0,539	0,567	0,590	0,539	0,567	0,590
1990	0,539	0,568	0,592	0,539	0,568	0,592
1991	0,554	0,584	0,599	0,554	0,584	0,599
1992	0,572	0,601	0,607	0,572	0,601	0,607
1993	0,591	0,620	0,616	0,591	0,620	0,616
1994	0,612	0,642	0,624	0,612	0,642	0,624
1995	0,635	0,666	0,634	0,635	0,666	0,634
1996	0,667	0,683	0,653	0,667	0,683	0,653
1997	0,706	0,702	0,675	0,706	0,702	0,675
1998	0,711	0,724	0,700	0,711	0,724	0,700
1999	0,733	0,749	0,729	0,733	0,749	0,729
2000	0,757	0,775	0,764	0,757	0,775	0,764
2001	0,737	0,753	0,790	0,737	0,753	0,790
2002	0,741	0,757	0,820	0,741	0,757	0,820
2003	0,765	0,785	0,859	0,765	0,785	0,859
2004	0,816	0,844	0,911	0,816	0,844	0,911
2005	0,786	0,809	0,858	0,786	0,809	0,858
2006	0,799	0,824	0,827	0,799	0,824	0,827
2007	0,802	0,827	0,830	0,802	0,827	0,830
2008	0,796	0,821	0,824	0,796	0,821	0,824
2009	0,796	0,821	0,824	0,796	0,821	0,824
2010	0,816	0,844	0,848	0,816	0,844	0,848
2011	0,822	0,852	0,855	0,822	0,852	0,855
2012	0,802	0,827	0,830	0,802	0,827	0,830
2013	0,825	0,856	0,859	0,825	0,856	0,859
2014	0,802	0,827	0,830	0,802	0,827	0,830
2015	0,816	0,844	0,848	0,816	0,844	0,848
2016	0,834	0,868	0,872	0,834	0,868	0,872
2017	0,838	0,872	0,876	0,838	0,872	0,876
2018	0,838	0,872	0,876	0,838	0,872	0,876
2019	0,841	0,877	0,881	0,841	0,877	0,881

Table A1.4: Calculated Literacy Index Escosura and Flora (EF) based and Vannebo, Johansson and Markussen (VJM) based literacy rates & Enrolment Index:

		Literacy Index EF			Literacy Index VJM			Enrolment Index	
	Sweden	Norway	Denmark	Sweden	Norway	Denmark	Sweden	Norway	Denmark
1810	0,247	0,301	0,324						
1811	0,249	0,303	0,326						
1812	0,251	0,305	0,329						
1813	0,253	0,308	0,331						
1814	0,255	0,310	0,334	0,036	0,043	0,065			
1815	0,257	0,312	0,336	0,037	0,044	0,067			
1816	0,259	0,314	0,339	0,037	0,045	0,068			
1817	0,261	0,317	0,341	0,038	0,046	0,069			
1818	0,264	0,319	0,344	0,039	0,047	0,070			
1819	0,266	0,321	0,347	0,040	0,047	0,071			
1820	0,268	0,324	0,349	0,040	0,048	0,073	0,063	0,101	0,101
1821	0,270	0,326	0,352	0,041	0,049	0,074	0,063	0,101	0,101
1822	0,273	0,329	0,355	0,042	0,050	0,075	0,063	0,101	0,101
1823	0,275	0,331	0,358	0,043	0,051	0,076	0,063	0,101	0,101
1824	0,277	0,334	0,361	0,044	0,052	0,077	0,063	0,101	0,101
1825	0,279	0,336	0,363	0,044	0,053	0,078	0,063	0,101	0,101
1826	0,282	0,339	0,366	0,045	0,054	0,079	0,063	0,101	0,101
1827	0,284	0,341	0,369	0,046	0,055	0,080	0,064	0,101	0,102
1828	0,287	0,344	0,372	0,047	0,057	0,081	0,064	0,101	0,102
1829	0,289	0,347	0,375	0,048	0,058	0,083	0,064	0,101	0,102
1830	0,292	0,349	0,378	0,049	0,059	0,084	0,064	0,101	0,102
1831	0,294	0,352	0,382	0,050	0,060	0,085	0,064	0,101	0,102
1832	0,297	0,355	0,385	0,051	0,061	0,087	0,064	0,101	0,102
1833	0,299	0,358	0,388	0,052	0,063	0,088	0,065	0,101	0,102
1834	0,302	0,361	0,391	0,053	0,064	0,089	0,065	0,101	0,102
1835	0,304	0,363	0,394	0,054	0,065	0,091	0,066	0,101	0,102
1836	0,307	0,366	0,398	0,055	0,066	0,092	0,067	0,101	0,102
1837	0,310	0,369	0,401	0,058	0,068	0,094	0,067	0,101	0,102
1838	0,313	0,372	0,405	0,061	0,071	0,098	0,068	0,102	0,102
1839	0,315	0,375	0,408	0,063	0,074	0,102	0,068	0,102	0,102

1840	0,318	0,378	0,412	0,066	0,077	0,106	0,069	0,102	0,102
1841	0,321	0,382	0,416	0,069	0,081	0,110	0,070	0,105	0,102
1842	0,324	0,385	0,419	0,073	0,084	0,115	0,071	0,104	0,102
1843	0,327	0,388	0,423	0,077	0,088	0,120	0,071	0,104	0,101
1844	0,330	0,391	0,427	0,082	0,092	0,125	0,071	0,103	0,101
1845	0,333	0,394	0,431	0,086	0,096	0,130	0,070	0,099	0,100
1846	0,336	0,398	0,435	0,091	0,100	0,136	0,070	0,099	0,100
1847	0,339	0,401	0,439	0,095	0,105	0,142	0,070	0,099	0,099
1848	0,342	0,405	0,443	0,100	0,109	0,149	0,069	0,098	0,099
1849	0,345	0,408	0,447	0,106	0,115	0,156	0,069	0,098	0,098
1850	0,348	0,412	0,452	0,111	0,120	0,164	0,069	0,097	0,098
1851	0,352	0,416	0,452	0,116	0,126	0,172	0,068	0,097	0,097
1852	0,357	0,419	0,453	0,121	0,132	0,181	0,068	0,096	0,097
1853	0,361	0,423	0,454	0,127	0,138	0,190	0,068	0,096	0,097
1854	0,365	0,427	0,455	0,134	0,143	0,197	0,068	0,095	0,096
1855	0,370	0,431	0,456	0,139	0,148	0,205	0,067	0,095	0,096
1856	0,374	0,435	0,457	0,144	0,154	0,213	0,067	0,095	0,095
1857	0,379	0,439	0,458	0,149	0,159	0,221	0,067	0,094	0,095
1858	0,384	0,443	0,459	0,155	0,165	0,231	0,067	0,094	0,095
1859	0,389	0,447	0,460	0,160	0,172	0,240	0,066	0,094	0,094
1860	0,394	0,452	0,460	0,166	0,178	0,251	0,066	0,093	0,094
1861	0,402	0,456	0,467	0,171	0,183	0,260	0,066	0,093	0,093
1862	0,411	0,460	0,473	0,176	0,188	0,269	0,066	0,092	0,093
1863	0,420	0,465	0,480	0,181	0,194	0,279	0,065	0,092	0,093
1864	0,430	0,469	0,487	0,186	0,200	0,289	0,065	0,092	0,092
1865	0,440	0,474	0,494	0,191	0,206	0,300	0,073	0,091	0,092
1866	0,450	0,479	0,502	0,200	0,212	0,312	0,075	0,091	0,092
1867	0,462	0,484	0,510	0,209	0,218	0,325	0,078	0,091	0,092
1868	0,474	0,489	0,518	0,219	0,225	0,339	0,082	0,090	0,092
1869	0,486	0,495	0,526	0,229	0,233	0,354	0,086	0,091	0,092
1870	0,500	0,500	0,535	0,241	0,240	0,371	0,088	0,091	0,093
1871	0,502	0,503	0,537	0,251	0,248	0,390	0,091	0,093	0,095
1872	0,503	0,505	0,538	0,262	0,257	0,410	0,093	0,094	0,097
1873	0,505	0,508	0,539	0,274	0,266	0,433	0,095	0,096	0,099
1874	0,506	0,511	0,540	0,287	0,275	0,438	0,098	0,098	0,101
1875	0,508	0,514	0,542	0,301	0,286	0,442	0,100	0,099	0,102
1876	0,509	0,517	0,543	0,309	0,297	0,447	0,102	0,100	0,103
1877	0,511	0,520	0,544	0,317	0,308	0,452	0,103	0,100	0,104
1878	0,513	0,523	0,546	0,326	0,321	0,457	0,104	0,101	0,104
1879	0,514	0,526	0,547	0,335	0,335	0,462	0,106	0,101	0,105
1880	0,516	0,529	0,548	0,344	0,349	0,467	0,109	0,102	0,105
1881	0,520	0,532	0,558	0,358	0,361	0,473	0,110	0,103	0,106
1882	0,524	0,535	0,568	0,373	0,372	0,478	0,110	0,104	0,107

1883	0,529	0,538	0,579	0,390	0,385	0,484	0,110	0,105	0,108
1884	0,533	0,542	0,590	0,408	0,399	0,490	0,110	0,106	0,109
1885	0,538	0,545	0,601	0,427	0,414	0,496	0,109	0,107	0,110
1886	0,542	0,548	0,614	0,440	0,427	0,503	0,109	0,107	0,111
1887	0,547	0,552	0,627	0,453	0,443	0,509	0,108	0,108	0,111
1888	0,552	0,555	0,642	0,468	0,460	0,516	0,107	0,109	0,112
1889	0,557	0,559	0,657	0,483	0,479	0,523	0,107	0,110	0,113
1890	0,562	0,562	0,673	0,500	0,500	0,530	0,106	0,111	0,114
1891	0,570	0,570	0,677	0,511	0,523	0,538	0,107	0,112	0,115
1892	0,577	0,577	0,681	0,523	0,548	0,545	0,108	0,113	0,116
1893	0,585	0,585	0,685	0,535	0,577	0,554	0,108	0,114	0,116
1894	0,593	0,593	0,688	0,548	0,611	0,562	0,108	0,115	0,118
1895	0,602	0,602	0,692	0,562	0,651	0,571	0,108	0,116	0,119
1896	0,611	0,611	0,696	0,584	0,662	0,580	0,108	0,117	0,120
1897	0,620	0,620	0,700	0,607	0,673	0,590	0,109	0,118	0,121
1898	0,630	0,630	0,704	0,634	0,686	0,600	0,109	0,119	0,122
1899	0,640	0,640	0,709	0,664	0,699	0,611	0,109	0,119	0,123
1900	0,651	0,651	0,713	0,699	0,713	0,622	0,109	0,121	0,124
1901	0,657	0,657	0,716	0,716	0,728	0,634	0,111	0,123	0,124
1902	0,664	0,664	0,720	0,734	0,744	0,647	0,113	0,126	0,124
1903	0,671	0,671	0,723	0,754	0,761	0,660	0,115	0,128	0,125
1904	0,679	0,679	0,727	0,776	0,780	0,675	0,117	0,131	0,125
1905	0,687	0,687	0,730	0,801	0,801	0,691	0,119	0,133	0,125
1906	0,695	0,695	0,734	0,810	0,810	0,707	0,121	0,136	0,125
1907	0,703	0,703	0,738	0,819	0,819	0,726	0,123	0,139	0,125
1908	0,712	0,712	0,741	0,829	0,829	0,746	0,125	0,141	0,126
1909	0,721	0,721	0,745	0,839	0,839	0,768	0,127	0,144	0,126
1910	0,730	0,730	0,749	0,849	0,849	0,793	0,130	0,147	0,126
1911	0,740	0,740	0,753	0,878	0,878	0,821	0,132	0,150	0,126
1912	0,750	0,750	0,757	0,912	0,912	0,854	0,135	0,154	0,126
1913	0,761	0,761	0,761	0,952	0,952	0,893	0,137	0,157	0,127
1914	0,761	0,761	0,765	0,979	0,979	0,940	0,134	0,156	0,126
1915	0,761	0,761	0,769	1,000	1,000	1,000	0,130	0,156	0,126
1916	0,761	0,761	0,773	1,000	1,000	1,000	0,127	0,155	0,125
1917	0,761	0,761	0,778	1,000	1,000	1,000	0,124	0,155	0,125
1918	0,761	0,761	0,782	1,000	1,000	1,000	0,121	0,154	0,124
1919	0,761	0,761	0,786	1,000	1,000	1,000	0,118	0,153	0,124
1920	0,761	0,761	0,790	1,000	1,000	1,000	0,115	0,153	0,123
1921	0,761	0,761	0,797	1,000	1,000	1,000	0,113	0,151	0,124
1922	0,761	0,761	0,803	1,000	1,000	1,000	0,111	0,149	0,125
1923	0,761	0,761	0,810	1,000	1,000	1,000	0,108	0,148	0,126
1924	0,761	0,761	0,817	1,000	1,000	1,000	0,106	0,146	0,126
1925	0,761	0,761	0,824	1,000	1,000	1,000	0,105	0,144	0,127

1926	0,761	0,761	0,843	1,000	1,000	1,000	0,104	0,144	0,127
1927	0,761	0,761	0,863	1,000	1,000	1,000	0,104	0,144	0,128
1928	0,761	0,761	0,886	1,000	1,000	1,000	0,104	0,144	0,128
1929	0,761	0,761	0,912	1,000	1,000	1,000	0,103	0,144	0,128
1930	0,761	0,761	0,912	1,000	1,000	1,000	0,105	0,146	0,129
1931	0,761	0,761	0,912	1,000	1,000	1,000	0,106	0,149	0,130
1932	0,761	0,761	0,912	1,000	1,000	1,000	0,107	0,151	0,131
1933	0,761	0,761	0,912	1,000	1,000	1,000	0,108	0,154	0,132
1934	0,773	0,773	0,912	1,000	1,000	1,000	0,107	0,157	0,130
1935	0,784	0,784	0,912	1,000	1,000	1,000	0,105	0,160	0,129
1936	0,797	0,797	0,912	1,000	1,000	1,000	0,103	0,164	0,127
1937	0,810	0,810	0,912	1,000	1,000	1,000	0,102	0,167	0,126
1938	0,824	0,824	0,912	1,000	1,000	1,000	0,100	0,171	0,124
1939	0,830	0,830	0,912	1,000	1,000	1,000	0,103	0,169	0,125
1940	0,836	0,836	0,912	1,000	1,000	1,000	0,106	0,167	0,127
1941	0,843	0,843	0,912	1,000	1,000	1,000	0,108	0,166	0,128
1942	0,849	0,849	0,912	1,000	1,000	1,000	0,111	0,164	0,129
1943	0,856	0,856	0,912	1,000	1,000	1,000	0,114	0,162	0,131
1944	0,863	0,863	0,912	1,000	1,000	1,000	0,118	0,161	0,132
1945	0,871	0,871	0,912	1,000	1,000	1,000	0,121	0,159	0,134
1946	0,878	0,878	0,912	1,000	1,000	1,000	0,124	0,158	0,135
1947	0,886	0,886	0,912	1,000	1,000	1,000	0,128	0,156	0,137
1948	0,895	0,895	0,912	1,000	1,000	1,000	0,131	0,155	0,138
1949	0,903	0,903	0,912	1,000	1,000	1,000	0,135	0,153	0,140
1950	0,912	0,912	0,912	1,000	1,000	1,000	0,139	0,152	0,141
1951	0,912	0,912	0,916	1,000	1,000	1,000	0,146	0,157	0,147
1952	0,912	0,912	0,921	1,000	1,000	1,000	0,154	0,162	0,153
1953	0,912	0,912	0,925	1,000	1,000	1,000	0,162	0,167	0,160
1954	0,912	0,912	0,930	1,000	1,000	1,000	0,171	0,173	0,166
1955	0,912	0,912	0,935	1,000	1,000	1,000	0,180	0,179	0,173
1956	0,921	0,921	0,940	1,000	1,000	1,000	0,182	0,183	0,174
1957	0,930	0,930	0,945	1,000	1,000	1,000	0,183	0,188	0,175
1958	0,940	0,940	0,950	1,000	1,000	1,000	0,184	0,192	0,176
1959	0,950	0,950	0,955	1,000	1,000	1,000	0,185	0,197	0,176
1960	0,960	0,960	0,960	1,000	1,000	1,000	0,186	0,202	0,177
1961	0,950	0,950	0,964	1,000	1,000	1,000	0,184	0,203	0,176
1962	0,940	0,940	0,968	1,000	1,000	1,000	0,182	0,205	0,175
1963	0,930	0,930	0,972	1,000	1,000	1,000	0,181	0,206	0,175
1964	0,921	0,921	0,975	1,000	1,000	1,000	0,179	0,207	0,174
1965	0,912	0,912	0,979	1,000	1,000	1,000	0,177	0,209	0,173
1966	0,927	0,927	0,983	1,000	1,000	1,000	0,187	0,219	0,188
1967	0,943	0,943	0,987	1,000	1,000	1,000	0,198	0,229	0,204
1968	0,960	0,960	0,991	1,000	1,000	1,000	0,210	0,241	0,223

1969	0,979	0,979	0,996	1,000	1,000	1,000	0,223	0,253	0,244
1970	1,000	1,000	1,000	1,000	1,000	1,000	0,237	0,267	0,269
1971	1,000	1,000	1,000	1,000	1,000	1,000	0,240	0,269	0,269
1972	1,000	1,000	1,000	1,000	1,000	1,000	0,243	0,272	0,269
1973	1,000	1,000	1,000	1,000	1,000	1,000	0,247	0,275	0,269
1974	1,000	1,000	1,000	1,000	1,000	1,000	0,250	0,277	0,269
1975	1,000	1,000	1,000	1,000	1,000	1,000	0,253	0,280	0,269
1976	1,000	1,000	1,000	1,000	1,000	1,000	0,261	0,284	0,281
1977	1,000	1,000	1,000	1,000	1,000	1,000	0,268	0,289	0,294
1978	1,000	1,000	1,000	1,000	1,000	1,000	0,277	0,293	0,307
1979	1,000	1,000	1,000	1,000	1,000	1,000	0,285	0,297	0,322
1980	1,000	1,000	1,000	1,000	1,000	1,000	0,294	0,302	0,338
1981	1,000	1,000	1,000	1,000	1,000	1,000	0,294	0,305	0,339
1982	1,000	1,000	1,000	1,000	1,000	1,000	0,294	0,309	0,340
1983	1,000	1,000	1,000	1,000	1,000	1,000	0,295	0,312	0,341
1984	1,000	1,000	1,000	1,000	1,000	1,000	0,295	0,316	0,342
1985	1,000	1,000	1,000	1,000	1,000	1,000	0,295	0,320	0,343
1986	1,000	1,000	1,000	1,000	1,000	1,000	0,294	0,320	0,344
1987	1,000	1,000	1,000	1,000	1,000	1,000	0,293	0,321	0,346
1988	1,000	1,000	1,000	1,000	1,000	1,000	0,292	0,321	0,347
1989	1,000	1,000	1,000	1,000	1,000	1,000	0,291	0,322	0,349
1990	1,000	1,000	1,000	1,000	1,000	1,000	0,290	0,322	0,350
1991	1,000	1,000	1,000	1,000	1,000	1,000	0,307	0,341	0,359
1992	1,000	1,000	1,000	1,000	1,000	1,000	0,327	0,361	0,369
1993	1,000	1,000	1,000	1,000	1,000	1,000	0,349	0,385	0,379
1994	1,000	1,000	1,000	1,000	1,000	1,000	0,374	0,412	0,390
1995	1,000	1,000	1,000	1,000	1,000	1,000	0,403	0,443	0,401
1996	1,000	1,000	1,000	1,000	1,000	1,000	0,445	0,467	0,426
1997	1,000	1,000	1,000	1,000	1,000	1,000	0,499	0,493	0,456
1998	1,000	1,000	1,000	1,000	1,000	1,000	0,505	0,524	0,490
1999	1,000	1,000	1,000	1,000	1,000	1,000	0,538	0,561	0,531
2000	1,000	1,000	1,000	1,000	1,000	1,000	0,573	0,601	0,584
2001	1,000	1,000	1,000	1,000	1,000	1,000	0,543	0,567	0,624
2002	1,000	1,000	1,000	1,000	1,000	1,000	0,549	0,574	0,673
2003	1,000	1,000	1,000	1,000	1,000	1,000	0,586	0,616	0,737
2004	1,000	1,000	1,000	1,000	1,000	1,000	0,665	0,713	0,830
2005	1,000	1,000	1,000	1,000	1,000	1,000	0,618	0,655	0,737
2006	1,000	1,000	1,000	1,000	1,000	1,000	0,638	0,679	0,684
2007	1,000	1,000	1,000	1,000	1,000	1,000	0,642	0,685	0,690
2008	1,000	1,000	1,000	1,000	1,000	1,000	0,634	0,674	0,679
2009	1,000	1,000	1,000	1,000	1,000	1,000	0,634	0,674	0,679
2010	1,000	1,000	1,000	1,000	1,000	1,000	0,665	0,713	0,719
2011	1,000	1,000	1,000	1,000	1,000	1,000	0,675	0,726	0,732

2012	1,000	1,000	1,000	1,000	1,000	1,000	0,642	0,685	0,690
2013	1,000	1,000	1,000	1,000	1,000	1,000	0,680	0,732	0,738
2014	1,000	1,000	1,000	1,000	1,000	1,000	0,642	0,685	0,690
2015	1,000	1,000	1,000	1,000	1,000	1,000	0,665	0,713	0,719
2016	1,000	1,000	1,000	1,000	1,000	1,000	0,696	0,753	0,760
2017	1,000	1,000	1,000	1,000	1,000	1,000	0,702	0,761	0,768
2018	1,000	1,000	1,000	1,000	1,000	1,000	0,702	0,761	0,768
2019	1,000	1,000	1,000	1,000	1,000	1,000	0,708	0,769	0,776

A2 Data used for calculating indices

Below are the GDP per capita used for calculating the income dimension. It is in G-K $1990 PPP adjusted for the relative differences of the US $2005 PPP differences. Also, the series we use for calculating the life expectancy (health) index are listed as life expectancy.

Table A2.1: Scandinavian GDP per capita in 1990 G-K$PPP & Life expectancy

		1990 G-K$PPP			Life Expectancy	
	Sweden	Norway	Denmark	Sweden	Norway	Denmark
1820	728,29	853,78	1141,97	43,14	46,96	40,23
1821	764,17	821,72	1184,14	39,00	44,69	38,14
1822	806,84	845,05	1189,49	43,36	46,13	42,76
1823	809,39	863,08	1172,76	46,37	48,76	45,19
1824	834,02	893,49	1190,83	44,56	47,64	44,97
1825	810,27	884,48	1185,48	43,14	49,23	45,24
1826	799,21	885,57	1187,48	40,26	47,63	43,08
1827	737,59	878,64	1209,57	41,11	48,38	42,64
1828	799,73	917,88	1216,27	36,64	46,22	37,74
1829	831,59	935,48	1186,82	31,02	46,29	36,18
1830	816,07	927,05	1192,84	34,11	45,75	40,97
1831	807,54	920,22	1182,13	29,25	45,66	38,98
1832	770,32	938,43	1214,26	32,53	47,62	40,84
1833	834,06	978,21	1198,19	36,20	44,86	42,50
1834	859,79	1001,60	1252,41	36,53	41,95	38,53
1835	853,07	999,44	1234,34	38,35	46,10	47,14
1836	860,02	979,51	1226,31	39,92	46,46	45,13
1837	846,91	982,12	1247,73	41,50	44,24	39,57
1838	817,35	992,62	1247,06	43,11	42,93	39,98
1839	837,40	1011,96	1251,08	41,86	43,05	39,88
1840	867,91	1045,79	1280,53	41,06	45,62	43,98

1841	862,15	1076,06	1267,81	42,64	49,51	45,17
1842	814,70	1076,92	1261,79	42,49	48,37	42,80
1843	847,93	1051,53	1323,37	43,85	48,44	42,82
1844	889,39	1063,74	1369,56	44,00	49,71	44,03
1845	915,96	1083,26	1390,98	43,35	50,07	45,99
1846	854,42	1105,00	1406,37	40,43	48,05	42,04
1847	870,87	1084,35	1387,63	40,47	44,77	40,12
1848	911,82	1052,85	1445,87	40,73	45,02	45,13
1849	965,81	1111,87	1516,82	39,50	48,05	44,50
1850	970,36	1160,10	1584,43	43,50	49,53	44,69
1851	951,81	1184,34	1490,05	44,57	49,74	43,62
1852	926,46	1205,30	1526,86	43,08	48,46	41,35
1853	938,67	1265,33	1517,49	38,60	47,92	39,99
1854	947,72	1323,13	1507,45	44,74	51,65	44,55
1855	1000,93	1355,19	1652,71	46,18	50,44	43,08
1856	996,34	1325,67	1538,91	46,78	50,37	42,14
1857	1026,11	1266,09	1543,60	42,49	50,22	34,64
1858	1060,15	1330,83	1513,47	40,04	51,59	42,00
1859	1126,18	1321,13	1594,47	44,42	49,93	44,27
1860	1155,30	1347,48	1561,67	45,11	50,00	48,47
1861	1144,00	1332,35	1567,02	47,65	45,81	47,12
1862	1065,50	1371,75	1595,14	47,62	44,70	42,55
1863	1138,09	1411,47	1676,13	47,58	46,71	45,38
1864	1161,96	1416,95	1643,33	40,20	48,78	44,77
1865	1195,97	1473,74	1681,49	39,85	50,42	45,40
1866	1169,80	1494,31	1667,43	42,95	49,92	44,73
1867	1191,95	1532,95	1650,03	44,97	47,87	46,18
1868	1025,78	1473,64	1662,08	45,66	47,16	43,23
1869	1147,53	1528,81	1739,73	46,13	49,25	40,96
1870	1346,80	1628,02	1796,62	46,06	50,86	45,01
1871	1386,35	1661,01	1787,25	46,15	49,69	48,98
1872	1431,30	1714,17	1871,59	47,53	50,02	50,08
1873	1470,08	1781,01	1848,17	47,58	49,67	48,68
1874	1438,31	1732,70	1888,33	46,11	47,77	44,28
1875	1458,47	1740,22	1906,40	44,51	47,64	44,61
1876	1541,19	1819,43	1927,82	45,88	46,83	44,81
1877	1513,44	1766,96	1855,53	47,41	49,77	46,04
1878	1483,33	1730,68	1910,42	47,60	51,79	46,72
1879	1574,49	1785,27	1956,61	46,29	53,18	48,91
1880	1514,92	1852,64	1991,41	44,86	51,91	47,61
1881	1549,22	1806,39	1996,77	48,37	50,47	48,49
1882	1519,44	1865,47	2054,33	46,77	47,40	48,58
1883	1626,65	1917,30	2112,57	48,56	49,64	49,04

1884	1620,01	1876,38	2104,54	48,60	50,80	49,16
1885	1656,84	1865,35	2098,51	49,69	51,05	48,92
1886	1641,25	1891,31	2160,77	49,00	51,71	50,58
1887	1612,71	1907,95	2219,67	48,71	51,68	51,44
1888	1689,43	1982,84	2219,00	46,71	50,37	52,33
1889	1658,18	2044,29	2233,73	47,83	49,05	52,28
1890	1734,56	2106,09	2354,22	47,30	48,59	50,46
1891	1699,97	2106,25	2389,03	46,83	49,78	51,07
1892	1787,85	2119,14	2433,87	47,49	49,67	50,59
1893	1862,16	2177,84	2468,01	47,14	51,40	51,34
1894	1876,53	2247,46	2500,14	49,42	50,61	52,07
1895	1940,37	2336,35	2611,93	50,93	52,79	54,13
1896	1996,18	2376,67	2679,54	52,98	53,83	53,46
1897	2077,75	2466,60	2711,00	51,85	53,72	54,11
1898	2134,44	2486,80	2723,05	53,14	53,95	54,66
1899	2228,33	2468,23	2807,39	50,70	51,61	50,92
1900	2209,68	2468,57	2875,00	51,94	53,46	52,24
1901	2239,03	2466,03	2964,70	52,65	54,58	52,89
1902	2221,51	2483,38	3006,20	54,73	56,48	54,72
1903	2333,00	2478,84	3155,47	54,80	54,97	55,05
1904	2409,42	2494,65	3195,63	55,80	56,08	55,36
1905	2397,45	2514,83	3222,41	54,40	55,09	54,51
1906	2580,31	2647,00	3282,65	56,59	56,90	56,66
1907	2736,37	2699,23	3371,01	56,12	56,48	56,94
1908	2675,76	2769,84	3441,96	54,95	56,30	56,38
1909	2658,51	2798,67	3537,02	57,43	57,46	58,37
1910	2783,54	2926,17	3605,29	58,08	57,97	57,75
1911	2862,22	3016,86	3727,12	57,00	58,02	57,98
1912	2949,27	3089,19	3659,51	58,08	57,73	57,74
1913	3116,79	3244,73	3729,80	58,92	58,30	58,63
1914	3078,08	3278,91	3891,79	58,52	57,80	58,21
1915	3146,72	3366,40	3551,74	58,45	58,15	57,15
1916	3323,09	3515,54	3632,74	56,96	57,23	58,16
1917	2903,80	3163,43	3352,94	57,30	57,73	58,84
1918	2826,54	3005,04	3183,58	56,24	50,28	49,76
1919	2856,01	3388,03	3527,65	56,99	56,80	56,51
1920	2968,57	3543,22	3622,03	57,54	58,87	58,75
1921	2652,08	3158,57	3446,65	61,77	61,59	60,97
1922	2939,33	3346,58	3725,78	60,64	60,77	60,98
1923	3022,59	3552,70	4046,42	61,21	61,79	62,93
1924	3174,68	3525,53	3989,52	61,18	62,10	61,93
1925	3167,57	3459,61	3828,87	61,95	62,50	62,49
1926	3379,84	3430,81	3990,19	61,70	63,24	62,72

1927	3477,59	3615,54	4012,28	61,23	62,85	61,52
1928	3546,62	3746,24	4090,60	61,92	63,38	62,20
1929	3805,42	3999,12	4304,80	61,99	62,45	62,24
1930	3944,51	4166,36	4544,44	62,30	64,08	63,11
1931	3897,48	3804,67	4316,01	61,88	64,11	62,61
1932	3719,90	3903,47	4452,49	62,72	64,58	63,87
1933	3841,50	4009,81	4655,50	63,64	65,46	64,75
1934	4072,83	4085,04	4767,98	64,13	66,19	64,89
1935	4322,92	4263,92	4851,65	62,90	65,81	64,77
1936	4571,45	4459,01	4951,10	63,48	65,81	64,52
1937	4673,36	4672,37	5049,86	63,96	66,01	64,54
1938	4842,06	4732,55	5148,62	64,97	67,06	65,48
1939	5270,21	4900,94	5371,52	65,81	67,33	66,30
1940	4786,35	4419,61	4599,26	66,25	65,86	66,64
1941	4771,10	4498,96	4123,97	66,00	65,74	66,93
1942	4799,45	4301,04	4186,38	67,14	65,65	68,87
1943	5017,69	4185,55	4608,18	67,44	66,09	68,62
1944	5117,93	3933,35	5043,69	66,39	65,77	67,64
1945	5164,78	4364,34	4623,27	66,07	68,16	68,23
1946	5651,84	4842,95	5287,16	67,22	69,48	69,40
1947	5958,00	5431,18	5540,24	68,52	69,97	69,36
1948	5978,17	5731,97	5646,54	70,10	71,09	70,62
1949	6051,22	5831,61	5997,01	70,13	71,49	70,68
1950	6420,63	6064,73	6430,46	70,31	71,56	71,02
1951	6594,80	6279,60	6614,09	70,91	72,50	71,25
1952	6643,61	6456,60	6678,05	70,76	72,63	71,74
1953	6757,89	6724,69	7093,79	71,13	73,11	71,78
1954	7134,53	7000,57	7090,95	71,33	73,19	72,23
1955	7318,16	7072,18	7096,63	71,90	73,40	72,47
1956	7507,69	7361,59	7162,72	72,03	73,45	72,53
1957	7616,69	7538,10	7768,20	71,79	73,40	72,36
1958	7738,11	7445,09	7946,58	72,22	73,39	73,01
1959	8106,69	7785,50	8567,69	72,19	73,52	73,23
1960	8410,71	8173,49	8565,56	72,18	73,54	72,90
1961	8853,53	8620,36	9085,76	72,44	73,55	73,36
1962	9225,38	8837,09	9608,10	72,32	73,43	73,23
1963	9690,01	9128,37	9642,21	72,41	73,06	73,42
1964	10321,03	9518,63	10526,27	72,49	73,56	73,59
1965	10620,63	9964,11	11011,65	72,37	73,68	73,73
1966	10730,89	10295,29	11232,66	72,45	73,96	73,98
1967	10983,12	10869,13	11585,86	72,93	74,03	74,01
1968	11332,74	11045,56	12090,43	73,14	73,91	73,88
1969	11843,58	11496,44	12899,16	73,23	73,62	74,00

1970	12422,53	11646,11	13336,75	73,35	74,03	74,55
1971	12454,69	12224,74	13668,29	73,49	74,19	74,65
1972	12702,15	12778,16	14122,85	73,62	74,38	74,76
1973	13181,77	13266,30	14613,07	73,83	74,55	74,92
1974	13563,36	13700,24	14383,18	74,00	74,74	75,00
1975	13856,98	14299,77	14131,68	74,13	74,85	75,06
1976	13952,54	15061,38	14930,55	74,18	75,04	75,18
1977	13681,54	15622,08	15161,96	74,44	75,29	75,39
1978	13880,79	16162,57	15450,94	74,44	75,45	75,54
1979	14380,82	16811,33	16008,01	74,42	75,55	75,61
1980	14597,09	17522,74	15912,02	74,38	75,75	75,86
1981	14645,90	17742,03	15812,21	74,45	75,92	76,17
1982	14819,88	17718,97	16407,63	74,57	76,04	76,44
1983	15094,28	18364,88	16846,74	74,59	76,13	76,69
1984	15717,61	19419,96	17558,88	74,67	76,20	76,88
1985	16032,13	20434,26	18254,76	74,71	76,15	76,91
1986	16424,28	21188,81	19662,52	74,85	76,22	77,04
1987	16918,55	21214,94	19146,28	74,97	76,25	77,11
1988	17273,31	21290,67	19132,49	75,05	76,44	77,21
1989	17612,88	21420,17	19248,40	75,11	76,68	77,51
1990	17609,00	21762,00	19502,00	75,20	76,85	77,64
1991	17290,01	22322,75	19720,04	75,32	77,12	77,81
1992	16989,17	22991,17	20039,89	75,39	77,27	78,10
1993	16541,49	23502,79	19972,51	75,43	77,40	78,31
1994	17076,86	24548,65	20968,84	75,48	77,69	78,47
1995	17666,69	25439,71	21504,53	75,57	77,93	78,84
1996	17923,36	26584,63	21993,62	75,88	78,18	79,08
1997	18468,21	27837,02	22611,99	76,19	78,32	79,29
1998	19244,47	28399,97	23035,10	76,45	78,40	79,41
1999	20058,49	28770,30	23633,96	76,56	78,50	79,51
2000	21002,60	29500,67	24441,40	76,92	78,71	79,66
2001	21253,61	29959,34	24555,21	77,12	78,91	79,81
2002	21649,80	30231,85	24582,52	77,28	79,11	79,96
2003	22053,74	30326,54	24614,30	77,52	79,46	80,11
2004	22917,47	31344,99	25210,26	77,78	79,82	80,23
2005	23486,89	31952,22	25723,16	78,08	80,11	80,50
2006	24430,13	32452,26	26641,23	78,34	80,35	80,74
2007	25081,59	33083,25	26770,19	78,61	80,52	80,90
2008	24826,80	32829,54	26473,12	78,91	80,69	81,06
2009	23573,29	31854,99	25037,46	79,17	80,86	81,27
2010	24819,75	31684,88	25395,56	79,49	81,04	81,52
2011	25385,12	31582,43	25628,79	79,84	81,23	81,68
2012	25038,71	32009,59	25590,33	80,14	81,48	81,76

2013	25097,53	31952,28	25727,96	80,39	81,73	81,89
2014	25532,50	32220,04	26005,63	80,66	82,01	82,07
2015	26380,72	32512,11	26432,13	80,74	82,07	82,06
2016	26680,00	32578,09	27066,23	80,82	82,09	82,05
2017	26957,79	33075,92	27435,36	80,96	82,24	82,21
2018	27239,40	33269,19	27960,54	81,10	82,39	82,37
2019	27296,82	33382,15	28499,08	81,24	82,55	82,53

(Edvinsson, 2013; Grytten, 2020; Hansen, 1983; Maddison, 2010; Gapminder, 2019).

Table A2.2: Scandinavian literacy rates based out of rates of Escosura and Flora (EF) and Vannebo, Johnasson and Markussen (VJM) & School enrolment rates:

		Literacy rates EF			Literacy rates VJM			School enrolment rates	
	Sweden	Norway	Denmark	Sweden	Norway	Denmark	Sweden	Norway	Denmark
1810	67,90	75,00	77,50						
1811	68,19	75,25	77,75						
1812	68,49	75,49	77,99						
1813	68,79	75,74	78,24						
1814	69,08	75,99	78,49	15,30	18,00	26,03			
1815	69,38	76,24	78,74	15,57	18,32	26,41			
1816	69,68	76,49	78,99	15,84	18,64	26,81			
1817	69,99	76,74	79,24	16,12	18,96	27,20			
1818	70,29	76,99	79,49	16,40	19,29	27,61			
1819	70,59	77,25	79,75	16,69	19,63	28,02			
1820	70,90	77,50	80,00	16,98	19,97	28,44	25,29	37,10	37,21
1821	71,19	77,75	80,25	17,28	20,32	28,77	25,30	37,11	37,23
1822	71,49	77,99	80,49	17,58	20,68	29,11	25,31	37,12	37,25
1823	71,79	78,24	80,74	17,89	21,04	29,45	25,32	37,14	37,27
1824	72,09	78,49	80,99	18,20	21,41	29,80	25,33	37,15	37,29
1825	72,38	78,74	81,24	18,52	21,78	30,16	25,34	37,16	37,31
1826	72,69	78,99	81,49	18,84	22,17	30,53	25,35	37,18	37,34
1827	72,99	79,24	81,74	19,17	22,55	30,90	25,37	37,19	37,36
1828	73,29	79,49	81,99	19,51	22,95	31,28	25,38	37,21	37,39
1829	73,59	79,75	82,25	19,85	23,35	31,68	25,39	37,22	37,41
1830	73,90	80,00	82,50	20,19	23,76	32,08	25,41	37,25	37,45
1831	74,19	80,25	82,75	20,55	24,17	32,48	25,43	37,27	37,49
1832	74,49	80,49	82,99	20,91	24,60	32,90	25,62	37,28	37,50

1833	74,79	80,74	83,24	21,27	25,03	33,33	25,81	37,29	37,51
1834	75,09	80,99	83,49	21,65	25,47	33,76	26,01	37,30	37,52
1835	75,39	81,24	83,74	22,02	25,91	34,21	26,20	37,31	37,53
1836	75,69	81,49	83,99	22,41	26,37	34,66	26,39	37,33	37,54
1837	75,99	81,74	84,24	23,47	26,83	35,13	26,59	37,34	37,55
1838	76,29	81,99	84,49	24,34	27,82	36,24	26,79	37,35	37,57
1839	76,59	82,25	84,75	25,27	28,88	37,44	26,98	37,36	37,58
1840	76,90	82,50	85,00	26,23	29,97	38,68	27,19	37,39	37,61
1841	77,19	82,75	85,25	27,31	31,03	39,88	27,66	38,32	37,48
1842	77,49	82,99	85,49	28,60	32,13	41,12	27,93	38,17	37,34
1843	77,79	83,24	85,74	29,94	33,27	42,41	27,83	38,03	37,21
1844	78,09	83,49	85,99	31,34	34,44	43,75	27,73	37,89	37,08
1845	78,39	83,74	86,24	32,81	35,66	45,14	27,62	36,73	36,93
1846	78,69	83,99	86,49	34,16	36,93	46,59	27,52	36,60	36,80
1847	78,99	84,24	86,74	35,56	38,23	48,09	27,42	36,47	36,67
1848	79,29	84,49	86,99	37,01	39,58	49,64	27,33	36,34	36,54
1849	79,59	84,75	87,25	38,53	40,98	51,26	27,23	36,21	36,41
1850	79,90	85,00	87,50	39,89	42,44	52,93	27,13	36,08	36,27
1851	80,27	85,25	87,55	41,30	43,94	54,67	27,03	35,95	36,15
1852	80,65	85,49	87,60	42,76	45,49	56,47	26,96	35,83	36,02
1853	81,02	85,74	87,65	44,39	47,10	58,34	26,86	35,70	35,89
1854	81,40	85,99	87,70	46,14	48,28	59,68	26,76	35,57	35,76
1855	81,78	86,24	87,75	47,29	49,48	61,06	26,67	35,44	35,63
1856	82,16	86,49	87,80	48,48	50,72	62,47	26,57	35,31	35,50
1857	82,54	86,74	87,85	49,69	51,99	63,92	26,50	35,22	35,41
1858	82,93	86,99	87,90	50,93	53,29	65,41	26,43	35,12	35,31
1859	83,31	87,25	87,95	52,20	54,62	66,94	26,35	35,01	35,20
1860	83,70	87,50	88,00	53,51	55,99	68,52	26,25	34,88	35,07
1861	84,31	87,75	88,34	54,47	57,00	69,75	26,16	34,76	34,96
1862	84,92	87,99	88,69	55,45	58,02	71,00	26,07	34,64	34,85
1863	85,54	88,24	89,04	56,45	59,07	72,28	25,98	34,52	34,75
1864	86,17	88,49	89,38	57,47	60,13	73,58	25,90	34,41	34,64
1865	86,79	88,74	89,73	58,50	61,21	74,91	28,39	34,31	34,59
1866	87,43	88,99	90,08	60,11	62,31	76,26	29,23	34,22	34,57
1867	88,06	89,24	90,44	61,77	63,43	77,63	30,18	34,16	34,55
1868	88,70	89,49	90,79	63,48	64,58	79,03	31,56	34,07	34,53
1869	89,35	89,75	91,14	65,23	65,74	80,45	32,61	34,14	34,48
1870	90,00	90,00	91,50	67,00	66,92	81,90	33,42	34,37	34,79
1871	90,07	90,12	91,55	68,54	68,13	83,37	34,13	34,80	35,33
1872	90,14	90,25	91,60	70,12	69,35	84,87	34,81	35,28	35,92
1873	90,21	90,37	91,65	71,73	70,60	86,40	35,49	35,75	36,50
1874	90,28	90,50	91,70	73,38	71,87	86,68	36,24	36,28	37,16
1875	90,35	90,62	91,75	75,00	73,17	86,96	36,79	36,61	37,52

1876	90,42	90,75	91,80	75,89	74,48	87,24	37,48	36,81	37,75
1877	90,49	90,87	91,85	76,78	75,82	87,53	37,79	36,98	37,92
1878	90,56	91,00	91,90	77,69	77,19	87,81	38,17	37,13	38,08
1879	90,63	91,12	91,95	78,60	78,58	88,10	38,58	37,31	38,28
1880	90,70	91,25	92,00	79,50	79,99	88,38	39,48	37,46	38,46
1881	90,88	91,37	92,34	80,77	80,99	88,67	39,68	37,70	38,68
1882	91,06	91,50	92,69	82,06	82,00	88,96	39,85	37,98	38,95
1883	91,24	91,62	93,04	83,38	83,03	89,25	39,87	38,27	39,24
1884	91,42	91,75	93,38	84,71	84,07	89,54	39,76	38,56	39,52
1885	91,60	91,87	93,73	86,00	85,12	89,83	39,48	38,82	39,79
1886	91,78	92,00	94,08	86,79	86,00	90,12	39,37	39,00	39,97
1887	91,96	92,12	94,44	87,59	87,00	90,41	39,06	39,18	40,13
1888	92,14	92,25	94,79	88,40	88,00	90,70	38,98	39,39	40,34
1889	92,32	92,37	95,14	89,21	89,00	91,00	38,81	39,62	40,54
1890	92,50	92,50	95,50	90,00	90,00	91,29	38,71	39,95	40,86
1891	92,75	92,75	95,57	90,50	91,00	91,59	38,90	40,17	41,07
1892	92,99	92,99	95,65	90,99	92,00	91,89	39,15	40,49	41,27
1893	93,24	93,24	95,72	91,49	93,00	92,19	39,29	40,77	41,44
1894	93,49	93,49	95,80	92,00	94,00	92,49	39,21	41,11	41,79
1895	93,74	93,74	95,87	92,50	95,00	92,79	39,06	41,41	42,08
1896	93,99	93,99	95,95	93,19	95,25	93,09	39,27	41,63	42,42
1897	94,24	94,24	96,02	93,89	95,50	93,39	39,36	41,85	42,69
1898	94,49	94,49	96,10	94,60	95,75	93,69	39,52	42,08	42,91
1899	94,75	94,75	96,17	95,31	96,00	94,00	39,45	42,31	43,19
1900	95,00	95,00	96,25	96,00	96,25	94,30	39,38	42,66	43,50
1901	95,15	95,15	96,31	96,30	96,50	94,61	39,91	43,28	43,55
1902	95,30	95,30	96,37	96,60	96,75	94,92	40,44	43,91	43,60
1903	95,46	95,46	96,42	96,90	97,00	95,22	40,98	44,55	43,66
1904	95,61	95,61	96,48	97,20	97,25	95,53	41,53	45,19	43,71
1905	95,76	95,76	96,54	97,50	97,50	95,84	42,09	45,85	43,77
1906	95,92	95,92	96,60	97,60	97,60	96,15	42,65	46,51	43,82
1907	96,07	96,07	96,65	97,70	97,70	96,47	43,22	47,18	43,87
1908	96,23	96,23	96,71	97,80	97,80	96,78	43,80	47,87	43,93
1909	96,38	96,38	96,77	97,90	97,90	97,09	44,38	48,56	43,98
1910	96,53	96,53	96,83	98,00	98,00	97,41	44,98	49,27	44,04
1911	96,69	96,69	96,88	98,25	98,25	97,72	45,58	49,98	44,09
1912	96,84	96,84	96,94	98,50	98,50	98,04	46,19	50,70	44,15
1913	97,00	97,00	97,00	98,75	98,75	98,36	46,81	51,44	44,20
1914	97,00	97,00	97,05	98,90	98,90	98,68	45,94	51,31	44,07
1915	97,00	97,00	97,11	99,00	99,00	99,00	45,09	51,18	43,94
1916	97,00	97,00	97,16	99,00	99,00	99,00	44,25	51,05	43,81
1917	97,00	97,00	97,21	99,00	99,00	99,00	43,43	50,92	43,67
1918	97,00	97,00	97,27	99,00	99,00	99,00	42,62	50,79	43,54

1919	97,00	97,00	97,32	99,00	99,00	99,00	41,83	50,66	43,41
1920	97,00	97,00	97,38	99,00	99,00	99,00	41,05	50,54	43,28
1921	97,00	97,00	97,45	99,00	99,00	99,00	40,47	50,14	43,49
1922	97,00	97,00	97,52	99,00	99,00	99,00	39,89	49,75	43,70
1923	97,00	97,00	97,60	99,00	99,00	99,00	39,32	49,36	43,91
1924	97,00	97,00	97,67	99,00	99,00	99,00	38,76	48,98	44,12
1925	97,00	97,00	97,75	99,00	99,00	99,00	38,21	48,59	44,33
1926	97,00	97,00	97,94	99,00	99,00	99,00	38,13	48,57	44,39
1927	97,00	97,00	98,12	99,00	99,00	99,00	38,06	48,55	44,44
1928	97,00	97,00	98,31	99,00	99,00	99,00	37,98	48,53	44,50
1929	97,00	97,00	98,50	99,00	99,00	99,00	37,91	48,50	44,56
1930	97,00	97,00	98,50	99,00	99,00	99,00	38,25	49,05	44,81
1931	97,00	97,00	98,50	99,00	99,00	99,00	38,60	49,60	45,07
1932	97,00	97,00	98,50	99,00	99,00	99,00	38,95	50,16	45,32
1933	97,00	97,00	98,50	99,00	99,00	99,00	39,30	50,72	45,58
1934	97,15	97,15	98,50	99,00	99,00	99,00	38,82	51,45	45,16
1935	97,30	97,30	98,50	99,00	99,00	99,00	38,35	52,19	44,74
1936	97,45	97,45	98,50	99,00	99,00	99,00	37,88	52,93	44,32
1937	97,60	97,60	98,50	99,00	99,00	99,00	37,42	53,69	43,91
1938	97,75	97,75	98,50	99,00	99,00	99,00	36,96	54,46	43,50
1939	97,81	97,81	98,50	99,00	99,00	99,00	37,73	54,09	43,85
1940	97,87	97,87	98,50	99,00	99,00	99,00	38,51	53,73	44,20
1941	97,94	97,94	98,50	99,00	99,00	99,00	39,31	53,38	44,55
1942	98,00	98,00	98,50	99,00	99,00	99,00	40,13	53,02	44,90
1943	98,06	98,06	98,50	99,00	99,00	99,00	40,96	52,67	45,26
1944	98,12	98,12	98,50	99,00	99,00	99,00	41,81	52,32	45,62
1945	98,19	98,19	98,50	99,00	99,00	99,00	42,68	51,97	45,98
1946	98,25	98,25	98,50	99,00	99,00	99,00	43,57	51,62	46,35
1947	98,31	98,31	98,50	99,00	99,00	99,00	44,47	51,28	46,72
1948	98,37	98,37	98,50	99,00	99,00	99,00	45,39	50,94	47,09
1949	98,44	98,44	98,50	99,00	99,00	99,00	46,34	50,60	47,46
1950	98,50	98,50	98,50	99,00	99,00	99,00	47,30	50,26	47,84
1951	98,50	98,50	98,53	99,00	99,00	99,00	49,00	51,40	49,20
1952	98,50	98,50	98,56	99,00	99,00	99,00	50,76	52,55	50,59
1953	98,50	98,50	98,59	99,00	99,00	99,00	52,58	53,74	52,03
1954	98,50	98,50	98,62	99,00	99,00	99,00	54,47	54,95	53,50
1955	98,50	98,50	98,65	99,00	99,00	99,00	56,43	56,19	55,02
1956	98,56	98,56	98,68	99,00	99,00	99,00	56,66	57,03	55,16
1957	98,62	98,62	98,71	99,00	99,00	99,00	56,90	57,89	55,30
1958	98,68	98,68	98,74	99,00	99,00	99,00	57,13	58,77	55,44
1959	98,74	98,74	98,77	99,00	99,00	99,00	57,37	59,65	55,59
1960	98,80	98,80	98,80	99,00	99,00	99,00	57,61	60,55	55,73
1961	98,74	98,74	98,82	99,00	99,00	99,00	57,22	60,79	55,57

1962	98,68	98,68	98,84	99,00	99,00	99,00	56,84	61,04	55,41
1963	98,62	98,62	98,86	99,00	99,00	99,00	56,45	61,29	55,25
1964	98,56	98,56	98,88	99,00	99,00	99,00	56,07	61,53	55,09
1965	98,50	98,50	98,90	99,00	99,00	99,00	55,69	61,78	54,93
1966	98,60	98,60	98,92	99,00	99,00	99,00	57,70	63,48	57,83
1967	98,70	98,70	98,94	99,00	99,00	99,00	59,78	65,22	60,90
1968	98,80	98,80	98,96	99,00	99,00	99,00	61,93	67,01	64,12
1969	98,90	98,90	98,98	99,00	99,00	99,00	64,16	68,85	67,52
1970	99,00	99,00	99,00	99,00	99,00	99,00	66,48	70,74	71,09
1971	99,00	99,00	99,00	99,00	99,00	99,00	66,94	71,08	71,09
1972	99,00	99,00	99,00	99,00	99,00	99,00	67,41	71,43	71,09
1973	99,00	99,00	99,00	99,00	99,00	99,00	67,88	71,77	71,09
1974	99,00	99,00	99,00	99,00	99,00	99,00	68,36	72,12	71,09
1975	99,00	99,00	99,00	99,00	99,00	99,00	68,84	72,47	71,09
1976	99,00	99,00	99,00	99,00	99,00	99,00	69,88	72,99	72,59
1977	99,00	99,00	99,00	99,00	99,00	99,00	70,94	73,52	74,13
1978	99,00	99,00	99,00	99,00	99,00	99,00	72,02	74,05	75,69
1979	99,00	99,00	99,00	99,00	99,00	99,00	73,11	74,58	77,29
1980	99,00	99,00	99,00	99,00	99,00	99,00	74,22	75,12	78,93
1981	99,00	99,00	99,00	99,00	99,00	99,00	74,23	75,50	79,02
1982	99,00	99,00	99,00	99,00	99,00	99,00	74,23	75,89	79,11
1983	99,00	99,00	99,00	99,00	99,00	99,00	74,24	76,28	79,20
1984	99,00	99,00	99,00	99,00	99,00	99,00	74,24	76,67	79,30
1985	99,00	99,00	99,00	99,00	99,00	99,00	74,25	77,06	79,39
1986	99,00	99,00	99,00	99,00	99,00	99,00	74,14	77,11	79,52
1987	99,00	99,00	99,00	99,00	99,00	99,00	74,03	77,17	79,66
1988	99,00	99,00	99,00	99,00	99,00	99,00	73,92	77,22	79,79
1989	99,00	99,00	99,00	99,00	99,00	99,00	73,81	77,28	79,93
1990	99,00	99,00	99,00	99,00	99,00	99,00	73,70	77,33	80,06
1991	99,00	99,00	99,00	99,00	99,00	99,00	75,72	79,18	80,88
1992	99,00	99,00	99,00	99,00	99,00	99,00	77,80	81,06	81,71
1993	99,00	99,00	99,00	99,00	99,00	99,00	79,94	83,00	82,55
1994	99,00	99,00	99,00	99,00	99,00	99,00	82,13	84,98	83,39
1995	99,00	99,00	99,00	99,00	99,00	99,00	84,39	87,00	84,25
1996	99,00	99,00	99,00	99,00	99,00	99,00	87,13	88,34	85,97
1997	99,00	99,00	99,00	99,00	99,00	99,00	89,95	89,69	87,73
1998	99,00	99,00	99,00	99,00	99,00	99,00	90,24	91,06	89,52
1999	99,00	99,00	99,00	99,00	99,00	99,00	91,60	92,45	91,35
2000	99,00	99,00	99,00	99,00	99,00	99,00	92,85	93,72	93,22
2001	99,00	99,00	99,00	99,00	99,00	99,00	91,81	92,66	94,35
2002	99,00	99,00	99,00	99,00	99,00	99,00	92,02	92,88	95,49
2003	99,00	99,00	99,00	99,00	99,00	99,00	93,26	94,14	96,64
2004	99,00	99,00	99,00	99,00	99,00	99,00	95,33	96,25	97,82

2005	99,00	99,00	99,00	99,00	99,00	99,00	94,19	95,09	96,64
2006	99,00	99,00	99,00	99,00	99,00	99,00	94,71	95,62	95,72
2007	99,00	99,00	99,00	99,00	99,00	99,00	94,81	95,72	95,82
2008	99,00	99,00	99,00	99,00	99,00	99,00	94,60	95,51	95,61
2009	99,00	99,00	99,00	99,00	99,00	99,00	94,60	95,51	95,61
2010	99,00	99,00	99,00	99,00	99,00	99,00	95,33	96,25	96,35
2011	99,00	99,00	99,00	99,00	99,00	99,00	95,53	96,46	96,56
2012	99,00	99,00	99,00	99,00	99,00	99,00	94,81	95,72	95,82
2013	99,00	99,00	99,00	99,00	99,00	99,00	95,64	96,57	96,66
2014	99,00	99,00	99,00	99,00	99,00	99,00	94,81	95,72	95,82
2015	99,00	99,00	99,00	99,00	99,00	99,00	95,33	96,25	96,35
2016	99,00	99,00	99,00	99,00	99,00	99,00	95,95	96,89	96,98
2017	99,00	99,00	99,00	99,00	99,00	99,00	96,05	96,99	97,08
2018	99,00	99,00	99,00	99,00	99,00	99,00	96,05	96,99	97,08
2019	99,00	99,00	99,00	99,00	99,00	99,00	96,16	97,10	97,19

(Johansson, 1977; Markussen, 1985; Vannebo, 1984; Escosura, 2020; Flora, 1973; Mitchell, 1998; Statistics Norway, 2020; and own estimations)

A3 Methods needed for calculating PPP adjusted GDP per capita

A3.1 Price Indices

The Paasche price index (P_P) is used to calculate the deflators (Grytten, 2020):

$$P_P = \frac{\sum(p_{i,t}) * (q_{i,t})}{\sum(p_{i,t=0}) * q(q_{i,t})}$$

p = price

q = volume

i = industry or sub-industry

t = time in period

t = 0 = base year

The deflation from the production side

To reach at fixed price series from the production side one in modern national accounts use a double deflation technique, i.e. deflating both the input and output series. This gives the value added in fixed prices:

$$y_{i,t}^{f} = \frac{q_{i,t}}{\frac{\sum(p_{i,t}) * (q_{i,t})}{\sum(p_{i,t=0)} * q(q_{i,t})}} - \frac{h_{i,t}}{\frac{\sum(p_{i,t}) * (q_{i,t})}{\sum(p_{i,t=0}) * q(q_{i,t})}}$$

y = value added

f = fixed prices

For most service industries, however, a single deflation technique is utilised. Implying one deflates the value-added series only:

$$y_{i,t}^{f} = \frac{(q_{i,t} - h_{i,t})}{\frac{\sum(p_{i,t}) * (q_{i,t})}{\sum(p_{i,t=0}) * q(q_{i,t})}}$$

By adding the sub-industry series, we get a value added per key industry (y) in fixed prices (f). If we add these again we receive the national GDP in fixed prices (Y^F). By dividing GDP in nominal prices (Y^N) with GDP in fixed prices (Y^F) we get the implicit GDP deflator (P_D^Y) at the aggregated level (Grytten, 2020):

$$P_D^Y = \frac{Y_t^N}{Y_t^N} = \frac{\sum(p_{i,t}) * (q_{i,t})}{\sum(p_{i,t=0}) * q(q_{i,t})}$$

P_D^Y = GDP deflator at aggregated level

Y^N = GDP in nominal prices

Y^F = GDP in fixed prices

f = fixed prices

y = value added per key industry

Deflation from the expenditure side

In a fixed price-period we find GDP in fixed prices (Y^F) from the expenditure side by deflating each post with each of their respective deflator (P_D^{μ}). For expenditure within private consumption we use an adjusted CPI, constructed as a Laspeyres index (L_P), in the historical series (Grytten, 2020):

$$L_P = \frac{\sum(p_{i,t}) * (q_{i,t=0})}{\sum(p_{i,t=0}) * q(q_{i,t=0})}$$

L_P =Laspeyres index

Y^F =GDP in fixed prices

P_D^{μ} = Deflator

Hence, we arrive at a Laspeyres deflator for private consumption expenditures (L_D^C). By adopting t-1 calculations we are able to operate with annual weights of quantities for modern data. We can then use the following equation for series until 1946 (Grytten, 2020):

$$Y_t^F = \frac{C}{L_D^C} + \frac{G}{P_D^G} + \frac{I}{P_D^I} + \frac{X}{P_D^X} + \frac{M}{P_D^M}$$

L_D^C = Private consumption expenditures

(Grytten, 2020).

Gross domestic product per capita based on nominal series in purchasing power parities.

A3.2 Purchasing Power Parity

To be able to create GDP comparable over time, borders and currencies a basis of comparisons must be made and calculated into the number. This is where the PPP, Purchasing Power Parities, is important. The GDP per capita are adjusted for the PPP for a specific year, we use the PPP 1990 US$ adjusted for the relative differences between Norway, Sweden and Denmark in PPP 2005 US$. Beneath you can see how GDP per capita adjusted for PPP can be calculated being provided two national sources, Z and W (Lindgren, 2008):

$$Y_{i,t} = I_{i,2005} * \frac{Z_{i,s}}{Z_{i,2005}} * \frac{W_{i,t}}{W_{i,s}}$$

$$I_{i,2005} = n_{i,2005} * PPP_{i,2005}$$

$Y_{i,t}$ = GDP per capita for country i in year t

$I_{i,t}$ = GDP per capita by PPP provided by the ICP (ICP (International Comparison Program) have data for GDP per capita for 2005 and utilize their own ICP PPP rates)

$Z_{i,t}$ = real GDP per capita provided by source Z

$W_{i,t}$ = real GDP per capita provided by source W

$n_{i,2005}$ = GDP per capita in local prices

$PPP_{i,2005}$ = Price-ratio in PPP

Purchasing Power Parity (PPP) based GDP per capita is the GDP converted to international dollars using certain PPP-rates, divided by the total population in a country or an economy. International dollars have the same purchasing power over GDP as the US dollars in the United States. The purchasing power parity, or PPP, between two countries, say X and Y, is the ratio of the number of units of the currency of country X needed to purchase in country X the same quantity of a specific good or service as one single unit of the currency of country Y will be able to buy in country Y. The PPP can be expressed in the currency of each of the countries and can be computed among a large number of countries and expressed in a single currency. However, the US dollar (US$) is most frequently used as the reference currency (Knoema, 2019).

The rates try to equalise the purchasing power of different currencies, eliminating the differences in price levels between countries. They construct a basket of goods and services priced in a sample of all those that are part of final expenditure (OECD). They proceed to look at how much each of these baskets would cost for each currency. If, for instance, one computer, one ton of rice and one ton of steel costs $1 800 in Wilmington, North Carolina and NOK16 182 in Bergen, the PPP exchange rate would be NOK8.99 for every $1. This however does not have to equal the actual exchange rate between the two currencies. Thus, defining the purchasing power of a country.

$$PPPrate_{X,i} = \frac{PPPrate_{X,b} * \frac{GDPdef_{X,i}}{GDPdef_{X,b}}}{PPPrate_{U,b} * \frac{GDPdef_{U,i}}{GDPdef_{U,b}}}$$

$PPPrate_{X,i}$ = PPP exchange rate of country X in year i

$PPPrate_{X,b}$ = PPP exchange rate of country X for the benchmark year

$PPPrate_{U,b}$ = PPP exchange rate for the United States (US) for the benchmark year (equal to 1)

$GDPdef_{X,i}$ = GDP deflator of country X for year i

$GDPdef_{X,b}$ = GDP deflator of country X for the benchmark year

$GDPdef_{U,i}$ = GDP deflator for the US for year i

$GDPdef_{U,b}$ = GDP deflator the the US for the benchmark year

When adjusting for another benchmark, or in our case another year than 2005, the national growth rate has to be adjusted in order to fit both of the benchmark years. The following equation can be used to calculate the new value for all the subsequent years. Here the first benchmark year is 1820 and the second 2005:

$$Y_{t,i} = X_{t,i} * K_i * (\frac{1}{K_i})^{(\frac{t-1820}{2005-1820})}$$

2005 = benchmark year

$X_{t,i}$ = the value implied by the unadjusted growth rate for year t for country i

$Y_{t,i}$ = new value for year t for country i

1820 = value for the first benchmark year

$K_i = \frac{Y_{1820,i}}{X_{1820,i}}$ = adjustment factor

At certain times one cannot get hold of the required data to calculate the GDP per capita adjusted for PPP. In those cases, the estimates have to be calculated by using regional averages (Lindgren, 2008). This could be done the following way:

$$Y_{t,i} = s_i * e^{\alpha} * X_{t,r}^{\beta}$$

$Y_{t,i}$ = adjusted value for country i in year t

$X_{t,r}$ = regional average for region r in year t

α & β = estimated coefficients in…

s_i = spread out factor country i

A4 Hodrick-Prescott Filter

This serves as a tool in structural time series analysis, separating observed time series (x_t) into trend components (g_t), cycle components (c_t), seasonal components (s_t) and irregular components (i_t):

$$x_t = f(g_t, c_t, s_t, i_t) \quad (39)$$

An arithmetic approach to this function gives the following relationship:

$$x_t = g_t + c_t + s_t + i_t \quad (40)$$

Here it is natural to consider i_t as the residual:

$$i_t = x_t - (g_t + c_t + s_t) \quad (41)$$

In the present analysis it is natural to see i_t and s_t as part of c_t. hence, a reduced form of equation (2) will be as in equation (4):

$$x_t = g_t + c_t \quad (42)$$

By using a Hoderick-Prescott filter one might identify these components. The HP-filter minimises the variance of c_t subject to a penalty for variation in the second difference of g_t:

$$\min_{g_t} \sum_{t=1}^{T}(x_t - g_t)^2 + \lambda \sum_{t=2}^{T-1}[(g_{t+1} - g_t) - (g_t - g_{t-1})]^2 \quad (43)$$

In equation (5) $(x_t - g_t)$ gives the cycle component of the time series, when $[(g_{t+1} - g_t) - (g_t - g_{t-1})]$ gives the difference in the trend growth rate from period t until t+1. Also, λ, controls the smoothness of the growth components of the time series.

One may calculate cycle components by deducting the trend component from the observed time series:

$$c_t = x_t - g_t \quad (44)$$

To be able to calculate relative gaps, which are far more relevant than absolute numbers in our analysis, we use logs of the parameters x_t and g_t, which also gives log values of c_t.

$$log(c_t) = log(x_t) - log(g_t) \quad (45)$$

By using the HP-filter from equation (5) on equation (6) one arrives at the following relationships:

$$\min_{g_t} \sum_{t=1}^{T}(x_t - g_t)^2 = x_t - \lambda \sum_{t=2}^{T-1}[(g_{t+1} - g_t) - (g_t - g_{t-1})]^2 \quad (46)$$

Here the cycle component is $\min_{g_t} \sum_{t=1}^{T}(x_t - g_t)^2$ is the residual. Applying this on equation (7) one arrives at relative deviations from the polynomial trend, i.e, relative cycles:

$$log(c_t) = log(x_t) - log(\lambda \sum_{t=2}^{T-1}[(g_{t+1} - g_t) - (g_t - g_{t-1})]^2) \quad (47)$$

High smoothing parameters give trends with minor fluctuations, and thus, significant cycles. A smoothing parameter equal to zero means that changes in the observed series should be explained by trend developments only. Thus, high smoothing parameters make cycles decisive components in time series. Low smoothing parameters give trends with large fluctuations, and thus, minor cycles. Rules of thumb suggest a smoothing-parameter of λ = 100 for annual figures, λ = 1,600 for quarterly figures, and λ = 14,400 for monthly figures. In line with similar analysis for business cycles, we have chosen to use a smoothing parameter of 2500 for our annual HIHD series (Grytten, 2019).