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Gang Liu

Measuring human capital for Norway 2007-2014

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Preface

This document is to outline the measurement of human capital for Norway, which applies the internationally recommended lifetime income approach, based on the Norwegian register-based database. It is an important step towards the comprehensive measurement of total national wealth for Norway.

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Statistisk sentralbyrå, 28. september 2018

Lise D. Mc Mahon

Abstract

Using the Norwegian register-based database, this document outlines the estimation of Norwegian human capital for 2007-2014. The estimated results must be interpreted as experimental and are not yet an official version of the value of the Norwegian human capital stock. The lifetime income approach employed in this study, compared to those applied before, has been moderated in several aspects, including a detailed implementation methodology, several practical assumptions, and the choice of exogenous parameters.

Given the assumed annual real income growth rate of 2.3% and discount rate of 5%, both the estimated total and active human capital, regardless of gender, show an increasing trend over the period 2007-2014 for Norway. In addition, the estimated stock values of both total and active human capital are several times larger than that of either fixed capital or oil and gas wealth, indicating that Norway is rich not only in natural resources, but also in human capital, and the latter is by far the most important component in the total Norwegian national wealth.

Finally, to align human capital measures with the Norwegian national accounts, the distribution of Norwegian active human capital by industry in 2014 is presented. Further industry distribution both for the Males and for the Females, as well as by different educational levels are also provided. The presented distributions have given rise to a number of interesting observations.

Contents

1. Introduction

Measuring human capital can serve a variety of purposes, e.g. to facilitate a better understanding of the driving forces behind economic growth (e.g. Barro and Sala-i-Martin, 1995; Arnold *et al*., 2007), to measure output and productivity performance of the education sector (e.g. Gu and Wong, 2010; Schreyer, 2010), and to gauge how well a country is managing its national wealth, so as to assess the long-term sustainability of its development path (UNECE, 2009; Arrow *et al*., 2012).

Moreover, measuring human capital can help discussions on 'beyond GDP' that have recently gained a resurgence, since the distribution of human capital across households and individuals and the non-economic benefits due to human capital investments are among the crucial determinants for people's 'quality of life' and well-being (e.g. Stiglitz *et al*., 2009; OECD, 2011, 2013, 2015, 2017).

Despite its high importance in many aspects, human capital has not yet been incorporated within the asset boundary of the latest System of National Accounts (SNA) (see United Nations, 2009; Eurostat, 2013). Empirical human capital models are usually based on various proxies of human capital measures. The diversity of the approaches to measuring human capital makes it hard to draw meaningful policy implications by comparing these estimates within and across countries.

There are many definitions of human capital in the literature. The OECD defines human capital broadly as "the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being" (OECD, 2001). The multi-facet nature of human capital concept makes the measurement of it, if not impossible, rather difficult in practice.

A suggested pragmatic way to start with is to only focus on economic benefits accruing to individuals due to education, and to compile the corresponding human capital satellite accounts, which should be separate from, but linked to the core system of current national accounts (see Liu and Fraumeni, 2014; Liu, 2015; UNECE, 2016).

There has been a number of country studies and international initiatives as regards human capital measurement.[1] And several empirical studies have found that human capital is by far the most important component of national wealth that consists of produced, natural, social and human capital (e.g. Greaker *et al*., 2005; Gu and Wong, 2008; World Bank, 2006, 2011; Hamilton and Liu, 2014).

Measuring human capital for Norway has been occasionally carried out in recent years at Statistics Norway. Greaker *et al*. (2005) made experimental estimates of the Norwegian human capital as a residual from accounting total national wealth for 1985-2004. By means of the lifetime income approach, Liu and Greaker (2009) estimated the Norwegian human capital for 2006.

The estimation of Norwegian human capital was also covered by several international studies, such as the OECD human capital project (see Liu, 2011), the World Bank comprehensive wealth accounts (World Bank, 2006, 2011, 2018), and the biennial United Nations' *Inclusive Wealth Reports* (UNU-IHDP and UNEP, 2012, 2014).

In terms of data sources, almost all these international studies used various survey data, such as national labour force surveys, as their main data inputs. In addition,

[1] For an overview, please refer to Liu and Fraumeni (2014) and UNECE (2016).

various measuring approaches were employed by these studies. The OECD project applied the lifetime income approach, while the United Nations' *Inclusive Wealth Reports* employed a different income-based approach.[2] The previous World Bank (2006, 2011) studies used the residual approach. After comparing with the OECD estimates (see Hamilton and Liu, 2014), and based on long discussions about the choice of methodology, the lifetime income approach was finally employed for measuring human capital in the latest World Bank wealth accounting (World Bank, 2018).

The purpose of this paper is to make an experimental estimate of the stock value of Norwegian human capital for the period of 2007-2014, by using the internationally recommended lifetime income approach. The main input data for this study is the time series of Norwegian register-based database (2007-2014), which is of apparently better quality than traditionally applied survey type data in this field.

In order to improve the measurement procedure for human capital at Statistics Norway, a number of detailed methodologies, technical assumptions, and parameter choices are updated, compared to those previously applied, when implementing the lifetime income approach in this experimental study. Such updates are not only to reflect the actual data situation in Norway, but can also be considered as the updates in general methodology when applying the lifetime income approach for measuring human capital in the field.

The rest of this paper is structured as follows. Section 2 outlines the preferred lifetime income approach for measuring human capital, and its detailed implementation methodology. Before that, a brief overview of currently available approaches for human capital measurement is also given. Section 3 discusses the data inputs used for implementing the lifetime income approach. In Section 4, some empirical estimates are presented. Section 5 concludes.

2. Human capital measurement

2.1. Approaches to measuring human capital

Generally speaking, current available approaches to measuring human capital can be divided into two broad categories: the indicators-based approaches,[3] and the monetary measures, with the latter being regarded by many as possible candidates that are of potential capability of being incorporated in the SNA in the future.

The monetary measures include the residual, the cost-based, and the income-based approaches. The residual approach measures human capital as the difference between total national wealth and the sum of produced, and natural capital (World Bank, 2006, 2011). Though easy to implement, the approach cannot explain what drives the observed changes of the human capital over time, thus offering less valuable information for possible policy interventions

The cost-based approach measures human capital by looking at the stream of past investments undertaken by individuals, households, employers and governments (e.g. Shultz, 1961; Kendrick, 1976; Eisner, 1985). On the contrary, the income-based approach measures human capital by looking at the stream of future earnings

[2] For discussions on the similarities and differences between the two approaches, see Fraumeni and Liu (2014).

[3] The indicators-based approach will not be discussed in this paper. However, for a balanced discussion on it and all other different approaches in terms of strengths and weaknesses for measuring human capital, please refer to Liu and Fraumeni (2014).

that human capital investment generates (Weisbrod, 1961; Graham and Webb, 1979; Jorgenson and Fraumeni, 1989, 1992a, 1992b).

Human capital investment can take various forms, characterized as both *lifelong*, in terms of learning from birth to death,[4] and *lifewide*, in terms of learning in various settings, including families, schools and workplaces. To measure the stock of human capital by accounting for all the costs related to these forms of investment is a formidable task.

On the other hand, human capital investment can generate a wide range of benefits, which can be used to facilitate the measurement of human capital from the output side. This is the basic rationale underlying the income-based approach, and in particular, the lifetime income approach. However, the implementation of the lifetime income approach will also face a lot of challenges, including the choice of some key parameters for measuring human capital.[5]

Drawing upon the experiences from both national and international studies in this field, the cost-based and the income-based approaches have been recommended for country experiments for constructing human capital (satellite) accounts (e.g. UNECE, 2016). In addition, using the lifetime income approach to measuring human capital is highly preferred by some researchers in this field (e.g. Liu, 2014; Liu and Fraumeni, 2016).

2.2. Lifetime income approach

The lifetime income approach, also called the Jorgenson-Fraumeni approach, applies the neoclassical theory of investment to human capital (see Jorgenson, 1967). According to this theory, the price of capital goods depends upon the discounted value of all future capital services derived from the investments. On a per capita basis, this means that the value of the human capital of an individual can be determined from that person’s discounted lifetime income.

The lifetime income approach brings together, through a consistent accounting structure, a broad range of factors that shape the stock of human capital of the population living in a country: these factors include not only the total population and its structure (characterised by age, gender and education), but also the expected lifespan of people (a measure that reflects health conditions), their educational attainment, and their labour market experiences (in terms of both employment probabilities and the earnings they gain if employed).

Moreover, this approach has some advantages that are not necessarily shared by other approaches. For instance, the extension of this approach naturally leads to an accounting system that could include values, volumes, and prices as basic elements. This opens the way to the construction of a sequence of accounts similar to those used for produced capital within the framework of the SNA (Fraumeni, 2009; UNECE, 2016).

Owing to a number of conceptual, methodological and data limitations, this study has restricted to measuring only the personal economic returns generated through market activities, which is reflected by the lifetime income that results from human capital investment and that accrues to individual persons.

This choice does not imply neglecting other benefits due to human capital

[4] For instance, before taking formal education, each individual has already accumulated a certain amount of human capital, to which new knowledge and competencies acquired through formal education add incrementally.

[5] More on this later.

investment that accrue to the society at large in terms of positive externalities, such as a more cooperative and harmonised society, nor other non-economic benefits that accrue to individuals, such as enhancement of subjective well-being. On the contrary, this choice simply recognizes that current valuation methodologies do not allow accounting for these other effects in a comprehensive and sensible way.

2.3. Implementation methodology

Let us focus on a population for which the stock value of human capital will be estimated. Quite often, such population refers to a working age population,[6] because human capital embodied in a working age population is regarded as being more relevant to current economic activities, and so deserves at least a separate treatment.

Since many labour market statistics published at Statistics Norway refer to people at the age range from 15 to 74, the working age population is therefore defined in this paper as all the people between age 15 and 74 that are drawn from the Norwegian register-based database.

The working age population as defined in this paper is different from that applied before. In Liu and Greaker (2009), it was defined as the people with age range of 15-67. Truncating the upper bound of age range at 67 was because in Norway the officially normal retirement age is 67. Thus, it was assumed that after 67 years old one can only receive zero labour income.

In reality, however, there are indeed some Norwegian people older than 67 are still active in labour market and thus earn accordingly labour incomes, partly due to pension reforms. Therefore, the upper bound is lifted up to age 74 in this study, thus implying that after 74 years old the labour income is zero.

As a result, the downward bias in previous human capital estimate due to truncation at lower age (67) is reduced to some extent in this study. Nonetheless, it will not have significant impact on the estimate for total human capital. One reason is that not too many people older than 67 are still working; and more important, elder people have in general lower lifetime income than their younger counterparts, simply because they have less remaining working years.

Sometimes the total employment (both employed and self-employed people) becomes focus because human capital embodied in both the employed (i.e. as employees) and the self-employed people is considered to be more relevant for national accounts purposes, such as, for productivity analysis. Therefore, we define in this paper the stock of human capital for the working age population as the *total human capital*, and that for the employment as *active human capital*.

Formally, the implementation of the lifetime income approach requires three steps in practice. First, a database containing the economic value of labour market activities for the chosen population cross-classified by various categories needs to be compiled. This database should include, at minimum, information on the number of people, their earnings (when employed), as well as their school enrolment rates, employment rates, and survival rates. All these data should, ideally, be cross-classified by age, gender, and the highest level of educational attainment achieved.

Second, an algorithm needs to be constructed for calculating the lifetime income for a representative individual in each category in the database. Except for the

[6] However, measuring human capital for the whole population was also undertaken by some studies (e.g. Jorgenson and Fraumeni, 1989).

current income, all other income streams take place in the future. In order to make prediction for the future income streams, the cross-sectional information drawn from the current database is employed for this purpose.

For instance, if not going to school, an individual of a given age, gender and educational level is assumed to have in year *t+1* the same lifetime labour income (adjusted by the real income growth rate expected in the future and by the survival rate of each person) of a person who, in year *t*, is one year older but has otherwise the same characteristics.

Third, the measures of lifetime income per capita estimated need to be applied to all individuals in each age/gender/education category in order to compute the human capital stock for that category. Summing up the stock of human capital across all categories yields an estimate of the aggregate value of the human capital stock for each country.

For a representative individual in each category in the database, the lifetime labour income is estimated as follows:

$$(1)\ LIN_{age}^{edu} = EMR_{age}^{edu} AIN_{age}^{edu} + \left\{1 - \sum_{\overline{edu}} ENR_{age+1}^{edu-\overline{edu}}\right\} SUR_{age+1}$$

$$*\ LIN_{age+1}^{edu}\{(1+r)/(1+\delta)\} + \sum_{\overline{edu}} ENR_{age+1}^{edu-\overline{edu}}$$

$$*\left\{\left(\sum_{t=1}^{t_{edu-\overline{edu}}} SUR_{age+t} LIN_{age+t}^{\overline{edu}}\{(1+r)/(1+\delta)\}^{t}\right)/t_{edu-\overline{edu}}\right\},$$

where LIN_{age}^{edu} is the present value of lifetime labour income for a representative individual with educational level of “edu” at the age of “age”; EMR_{age}^{edu} is the employment rate for this individual; AIN_{age}^{edu} is his/her current annual labour income, if being employed; $ENR_{age+1}^{edu-\overline{edu}}$ is the school enrolment rate for a representative individual with educational level of “edu” pursuing his/her studies into a higher educational level of “$\overline{edu}$”; SUR_{age} is the probability of surviving one more year given that this individual is at the age of “age”; r is the annual growth rate of the labour income (in real terms) in the future; δ is the annual real discount rate; $t_{edu-\overline{edu}}$ is the school duration for an individual with educational level of “edu” to complete a higher educational level of “$\overline{edu}$”.

A representative individual in the next year will be confronted to two courses of action: the first is to continue his/her work (holding the same educational level as before) and earn income as $SUR_{age+1} LIN_{age+1}^{edu}\{(1+r)/(1+\delta)\}$, with the probability of $\left\{1 - \sum_{\overline{edu}} ENR_{age+1}^{edu-\overline{edu}}\right\}$; the second is to enter into school and (after completing study and having gained a higher educational level) to receive income as $\left\{\left(\sum_{t=1}^{t_{edu-\overline{edu}}} SUR_{age+t} LIN_{age+t}^{\overline{edu}}\{(1+r)/(1+\delta)\}^{t}\right)/t_{edu-\overline{edu}}\right\}$, with the probability of $\sum_{\overline{edu}} ENR_{age+1}^{edu-\overline{edu}}$. Therefore, his/her lifetime income in the next year is the expected value of the outcomes of these two courses of action (i.e. the sum of the second and the third terms in equation (1)).

The empirical implementation of equation (1) is based on the method of backwards recursion. By this approach, the lifetime labour income of a person aged 74 (i.e. one year before retirement) is simply his/her current labour income (the first term in equation (1) because his/her lifetime labour income at 75 is zero by construction. Similarly, the lifetime labour income of a person aged 73 is equal to his current labour income plus the present value of the lifetime labour income of a person aged 74, and so forth.

Note that in equation (1), it is allowed that each individual in the working age population (between age 15 and 74), no matter how old, has the possibility of studying at a higher educational level in the next year. This is different from previous practices where one special ‘study-and-work’ stage was purposely separated from the whole life cycle, and the cut-off of age after when no further studying possibility is allowed is usually arbitrarily chosen. People on the different stages of life cycle will be treated differently for lifetime income estimation (see e.g. Jorgenson and Fraumeni, 1989, 1992a, 1992b; Wei, 2007; Liu, 2011).

One reason for choosing a separate ‘study-and-work’ stage with a cut-off age is that in reality people beyond certain age do have little chance for further study. Another reason, presumably more important, is that it is hard to find the corresponding enrolment data needed for calculating lifetime income for people after certain age.

Recognising that nowadays in Norway, possibly in many other advanced countries as well, lifelong study has become more and more popular, and that further study will significantly improve people’s lifetime incomes, it has been decided that the previously division of people’s life cycle into separate stages should be dropped.

As a result, every individual in the working age population is treated equally in terms of lifetime income estimation, thus it is one and only one equation, i.e. equation (1) that is applied for the whole population. Such methodology update is further supported by the fact that the actual enrolment data at each age can be derived endogenously from the main input data, i.e. the Norwegian register-based database.

With the estimated lifetime income for a representative individual in each age/gender/education category, the total stock of human capital (HCV) is computed as:

(2) $$HCV = \sum_{age} \sum_{edu} AIN_{age}^{edu} \, NUM_{age}^{edu},$$

where NUM_{age}^{edu} is the number of persons in the corresponding age/education category, either from the working age population, if the *total human capital* is to be measured; or from the total employment, consisting of the employed (i.e. as employees) and the self-employed, if the *active human capital* is to be measured.

It should be noted that equations (1) and (2) are applied separately to the Males and the Females, and therefore, the super- and sub-script of gender is suppressed from (1) and (2). Calculating human capital separately for the Males and the Females allows computing the stock of human capital by gender.

The estimation of human capital based on the lifetime income approach depends upon a number of either explicit or implicit assumptions. In the following, some of them will be discussed in more detail.

The first is that an individual’s labour compensation, typically proxied by his/her earnings, should be equal to the marginal product of labour, and that earnings’ differentials between two individuals or population groups fully reflect the differences in their labour productivities.

Strictly speaking, this assumption only holds in perfect markets. In reality, there exist many reasons why labour markets do not always function in a perfect way. For instance, non-market factors such as institutional settings may play an important role in determining earnings. It follows that earnings are not always equal to the marginal value of a particular type of human capital, nor their differences reflect differentials of earnings' power.

One well-known example is that observed higher average earnings for the Males do not necessarily reflect their higher productivity compared to the Females with the same age and education; but rather reflect gender discrimination due to historical and cultural reasons. Other examples include: trade unions may command a premium wage for their members; and real wages may fall in economic recessions. In spite of these limitations, until better measures can be found, earnings are still applied as a first approximation to the marginal product of labour in practice.

The fundamental assumption as applied in the second step as outlined above reflects the use of cross-sectional information to reduce the burden of data requirements and simplify the calculation. However, using current earnings as a proxy for expected future earnings is problematic in some cases. For example, individual earnings are typically affected by a 'cohort effect', which means that a person born, say, in the 21st century may expect different future earnings from another person with similar educational qualifications born in the 1990s.

In addition, the use of current earnings to estimate lifetime income implies that, in recession years, higher unemployment/underemployment rates together with depressed wages will lead to an underestimate of the true value of human capital, while in boom years the use of these data will lead to an overestimation.

A natural way of addressing these issues would be to use not only cross-sectional but also time-series information in order to capture 'cohort effect' and business cycle effects, and thereby obtain a better measure of expected future earnings. For example, longitudinal data that follows the same people over time may be applied for this purpose.[7]

When applying equation (1), one implicit assumption made is that students enrolled in educational institutions requiring more than one year to complete are assumed to be evenly distributed across the total study-period (school duration).

This assumption is equivalent to say that, during each school-year, there is the same (equal) proportion of the total students that will complete the study. Another justification for taking even distribution across the total study-period is that almost within each educational level in Norway, the school duration varies.

For instance, although the school duration for post-secondary non-tertiary education (Level 5) is in general three years, there are many fields within this level having school duration of one, or two years (see Barrabes and Østli, 2016).

3. Data

The primary input data used for measuring human capital for Norway in this paper is the Norwegian register-based datasets for employment that are compiled by Statistics Norway for each year. These databases are based on various Norwegian

[7] In all cases, however, since we are dealing with expected future earnings, a variable for which no fully adequate measure currently exists, it seems natural to make inferences about the future based on current and past information. What should be kept in mind is that historical patterns may not repeat themselves.

administrative registered data sources and serve as the basic file from which a number of statistics associated with employment/unemployment, education, income, immigration, etc. can be derived (see Aukrust *et al*., 2010). The original datasets for 2007-2014 are placed in an internal LINUX server at Statistics Norway with the directory path as: $SYSDEF/reg_total/wk48.

Using Year 2014 as an example, the total number of persons covered by the register-based dataset for 2014 is 4,525,571, accounting for about 88% of the total population (5,137,679) in Norway.[8] The number of working age population as defined in this paper (i.e. people aged 15-74 drawn from the register-based database) is 4,165,738, roughly 92% of the total number in the register-based dataset in 2014.

Table 3.1. Norwegian standard classification of education

Tripartition of levels	Level	Level name	Class level
	0	No education and pre-school education	0
Compulsory education	1	Primary education	1 - 7
	2	Lower secondary education	8 - 10
Intermediate education	3	Upper secondary, basic	11 - 12
	4	Upper secondary, final year	13 +
	5	Post-secondary non-tertiary education	14 +
Tertiary education	6	First stage of tertiary education, undergraduate level	14 - 17
	7	First stage of tertiary education, graduate level	18 - 19
	8	Second stage of tertiary education (postgraduate)	20 +
	9	Unspecified	

Source: Barrabes and Østli (2016).

The Norwegian Standard Classification of Education (NUS2000) is frequently used for grouping peoples' education activities and education background. This standard is a 6-digit code system that classifies educational activities by level and field. It is used in Statistic Norway's statistics, including the register-based database, where education is included as a variable. In Table 3.1, some of the detailed information about the Norwegian standard classification of education is presented.

3.1. Working age population

By using the Norwegian standard classification of education (NUS2000), the distribution of the working age population by educational level in 2014 is presented for the whole working age population in Table 3.3, and for Male and Female in Table 3.4 and Table 3.5, respectively.

Table 3.2. Working age population by educational level in 2014

Educational level	Frequency (persons)	Percent (%)	Cumulative Frequency	Cumulative Percent
Primary education	446 079[a]	10.71[b]	446 079	10.71
Lower secondary education	957 837	22.99	1 403 916	33.70
Upper secondary, basic	394 005	9.46	1 797 921	43.16
Upper secondary, final year	1 045 683	25.10	2 843 604	68.26
Post-secondary non-tertiary education	108 714	2.61	2 952 318	70.87
First stage of tertiary education, undergraduate	891 943	21.41	3 844 261	92.28
First stage of tertiary education, graduate	290 212	6.97	4 134 473	99.25
Second stage of tertiary education, postgraduate	31 265	0.75	4 165 738	100.00

Notes:

a. Including 217,874 persons with missing values, 11,015 persons with either no or pre-school education (Level 0 as defined in Table 3.1) and 201,579 persons with unspecified education (Level 9 as defined in Table 3.1).

b. Including 5.23% missing values, 0.26% Level 0 and 4.84% Level 9.

Source: Author's calculation based on register-based database.

For simplicity, the category of primary education (Level 1) in the three tables (Table 3.2, Table 3.3 and Table 3.4) contains the number of persons with missing values, with either no or pre-school education (Level 0), as well as with unspecified education (Level 9). Biases may result from such a simplification of

[8] The total population of 5,137,679 refers to that at the beginning of the third quarter in 2014 (see Table 01222 in Statbank at Statistics Norway), since the register-based data is usually collected in November for each year.

treatment. However, without further information, it is hard to make assessment about either the bias direction (upward or downward) or the extent.

For the working age population in total, Table 3.2 shows that in 2014 the largest sub-population is that with Level 4 education (Upper secondary, final year), the second largest is that with Level 2 education (Lower secondary education), and the third is that with Level 6 education (First stage of tertiary education, undergraduate).

Table 3.3. Working age population by educational level in 2014 (Male)

Educational level	Frequency (persons)	Percent (%)	Cumulative Frequency	Cumulative Percent
Primary education	270 271	12.61	270 271	12.61
Lower secondary education	498 907	23.28	769 178	35.89
Upper secondary, basic	169 369	7.90	938 547	43.80
Upper secondary, final year	595 409	27.78	1 533 956	71.58
Post-secondary non-tertiary education	71 338	3.33	1 605 294	74.91
First stage of tertiary education, undergraduate	359 329	16.77	1 964 623	91.68
First stage of tertiary education, graduate	158 714	7.41	2 123 337	99.08
Second stage of tertiary education, postgraduate	19 643	0.92	2 142 980	100.00

Source: Author's calculation based on register-based database.

Table 3.4. Working age population by educational level in 2014 (Female)

Educational level	Frequency (persons)	Percent (%)	Cumulative Frequency	Cumulative Percent
Primary education	175 808	8.69	175 808	8.69
Lower secondary education	458 930	22.69	634 738	31.38
Upper secondary, basic	224 636	11.11	859 374	42.49
Upper secondary, final year	450 274	22.26	1 309 648	64.75
Post-secondary non-tertiary education	37 376	1.85	1 347 024	66.59
First stage of tertiary education, undergraduate	532 614	26.33	1 879 638	92.92
First stage of tertiary education, graduate	131 498	6.50	2 011 136	99.43
Second stage of tertiary education, postgraduate	11 622	0.57	2 022 758	100.00

Source: Author's calculation based on register-based database.

The ranking of the first three education categories for the whole working age population is the same for the Males only, as shown by Table 3.3. However, for the Females, as shown by Table 3.4, the largest sub-population is that with Level 6 education (First stage of tertiary education, undergraduate), the second largest is that with Level 2 education (Lower secondary education), and the third is that with Level 4 education (Upper secondary, final year).

3.2. Population of the employment

In this study, we have a special focus on people of employment (consisting of all people aged 15-74 who are either employed as employees or self-employed), with the purpose of being in more consistence with labour force accounts that are within the Norwegian national accounts system.

Table 3.5. Employment (emplyees + self-employed) by educational level in 2014

Educational level	Frequency (persons)	Percent (%)	Cumulative Frequency	Cumulative Percent
Primary education	234 738[a]	7.97[b]	234 738	7.97
Lower secondary education	543 680	18.47	778 418	26.44
Upper secondary, basic	216 403	7.35	994 821	33.79
Upper secondary, final year	838 271	28.48	1 833 092	62.27
Post-secondary non-tertiary education	87 921	2.99	1 921 013	65.26
First stage of tertiary education, undergraduate	739 190	25.11	2 660 203	90.37
First stage of tertiary education, graduate	255 039	8.66	2 915 242	99.03
Second stage of tertiary education, postgraduate	28 451	0.97	2 943 693	100.00

Notes:

a. Including 132,993 persons with missing values, 3,496 persons with either no or pre-school education (Level 0 as defined in Table 3.1) and 91,356 persons with unspecified education (Level 9 as defined in Table 3.1).

b. Including 4.52% missing values, 0.12% Level 0 and 3.10% Level 9.

Source: Author's calculation based on register-based database.

The distribution of the employment population by education is presented in Table 3.5 (for the employment in total), Table 3.6 (for Male employment) and Table 3.7

(for Female employment), similarly with the corresponding Table 3.2, Table 3.3 and Table 3.4 as regards the working age population.

For the employment in total, Table 3.5 shows that in 2014 the largest subgroup is that with Level 4 education (Upper secondary, final year), the second largest is that with Level 6 education (First stage of tertiary education, undergraduate), and the third is that Level 2 education (Lower secondary education). The first three education categories are the same as, but the exact ranking is slightly different from, those for the total working age population (see Table 3.3).

Table 3.6. Employment (emplyees + self-employed) by educational level in 2014 (Male)

Educational level	Frequency (persons)	Percent (%)	Cumulative Frequency	Cumulative Percent
Primary education	165 840	10.53	165 840	10.53
Lower secondary education	301 964	19.18	467 804	29.71
Upper secondary, basic	104 852	6.66	572 656	36.37
Upper secondary, final year	486 379	30.89	1059 035	67.26
Post-secondary non-tertiary education	59 313	3.77	1118348	71.03
First stage of tertiary education, undergraduate	299 118	19.00	1417466	90.03
First stage of tertiary education, graduate	139 039	8.83	1556505	98.86
Second stage of tertiary education, postgraduate	18 004	1.14	1574509	100.00

Source: Author's calculation based on register-based database.

Table 3.7. Employment (emplyees + self-employed) by educational level in 2014 (Female)

Educational level	Frequency (persons)	Percent (%)	Cumulative Frequency	Cumulative Percent
Primary education	68 898	5.03	68 898	5.03
Lower secondary education	241 716	17.65	310 614	22.69
Upper secondary, basic	111 551	8.15	422 165	30.83
Upper secondary, final year	351 892	25.70	774 057	56.53
Post-secondary non-tertiary education	28 608	2.09	802 665	58.62
First stage of tertiary education, undergraduate	440 072	32.14	1 242 737	90.76
First stage of tertiary education, graduate	116 000	8.47	1 358 737	99.24
Second stage of tertiary education, postgraduate	10 447	0.76	1 369 184	100.00

Source: Author's calculation based on register-based database.

For the Males, as shown by Table 3.6, the largest sub-population is that with Level 4 education (Upper secondary, final year), the second largest is that with Level 2 education (Lower secondary education), and the third is that with Level 6 education (First stage of tertiary education, undergraduate). Clearly, the first three education categories and the exact ranking are the same as those for the Male working age population (see Table 3.4).

While for the Females, Table 3.7 shows that the largest sub-population is that with Level 6 education (First stage of tertiary education, undergraduate), the second largest is that with Level 4 education (Upper secondary, final year), and the third is that with Level 2 education (Lower secondary education). As seen, the first three education categories are the same as, but the exact ranking is slightly different from, those for the Female working age population (see Table 3.5).

3.3. Employment rate

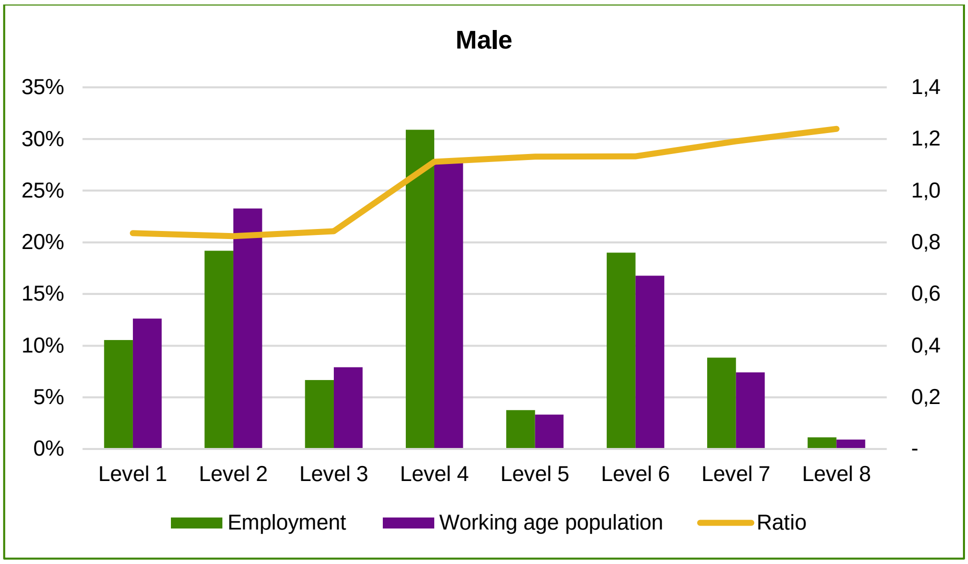
In the Norwegian register-based database, all people are classified by one variable ('yrkstat') indicating their labour market status in the year, which has the following values and the corresponding interpretations:

0 = Out of labour force;
1 = employed (i.e. as employees);
2 = Self-employed;
3 = Unemployed;
4 = Job-searching.

Figure 3.1. Comparison of education distribution in 2014 (Total)

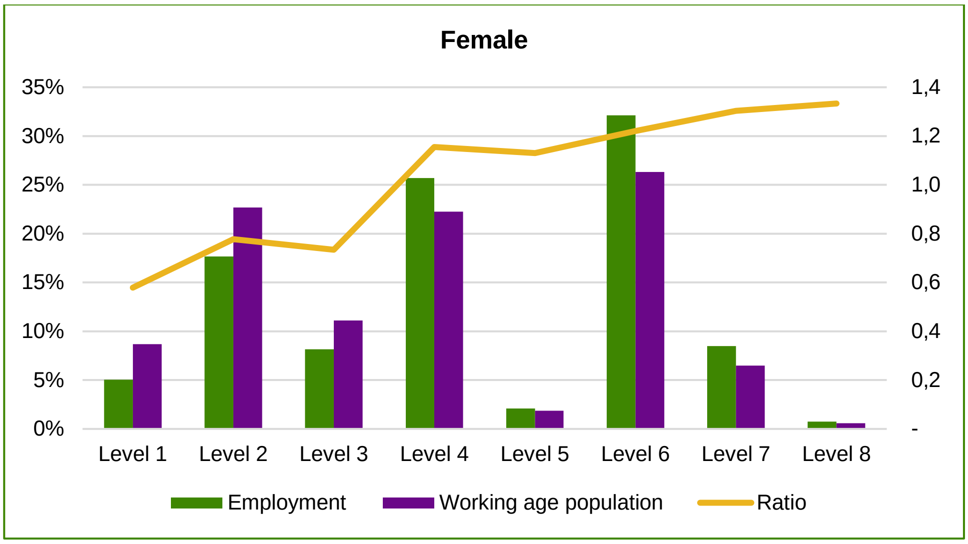
Source: Author's calculation based on register-based database.

Figure 3.2. Comparison of education distribution in 2014 (Male)



Source: Author's calculation based on register-based database.

Figure 3.3. Comparison of education distribution in 2014 (Female)



Source: Author's calculation based on register-based database.

The employment rate with certain age and education (EMR_{age}^{edu}) is therefore defined as the number of people with this specific age and education who are either employed (as employees) or self-employed (i.e. the value of 'yrkstat' is either 1 or 2), divided by the total number of people within this specific age and education category in the working age population.

To obtain a brief overview, some employment rates at the aggregate level are calculated. For example, the aggregate employment rate for the Norwegian working age population (i.e. all people aged 15-74) can be calculated as the total number of the employment (2,943,693) divided by the total number of the working age population (4,165,738) (see Table 3.2 and Table 3.5), which is about 71%.

Regardless of age and education, and based on Table 3.3 and Table 3.6, the aggregate employment rate for the Males is calculated as 1,574,509/2,142,980, which is around 73%. Similarly, drawing from Table 3.4 and Table 3.7, the aggregate employment rate for the Females is estimated to be roughly 68%.

Figures 3.1, 3.2 and 3.3 provide the distribution comparisons of people with different educational levels between the working age population and the employment population in 2014 for Total, the Males, and the Females, respectively. All the figures are extracted from the column of 'Percent' in Tables from 3.2 to 3.7.

All three figures demonstrate that for lower educational levels (i.e. from Level 1 to Level 3), their shares in the employment population are lower than the corresponding shares in the working age population. On the contrary, for higher educational levels (i.e. from Level 4 to Level 8), the opposite is true, i.e. their shares in the employment population are higher than the corresponding shares in the working age population. This implies that the employment rates for people with higher educational levels are higher than those with lower educational levels, and it holds for both the Males and the Females.

The 'Ratio', which denotes the lines in Figures 3.1, 3.2, and 3.3, is defined as the share in the employment divided by that in the corresponding working age population. As displayed, the lines are non-decreasing at least for the higher educational levels (i.e. Level 4 to Level 8), indicating again that the employment rates increase in general when educational level improves.

Table 3.8. Employment rate by gender and education (%) in 2014

Educational level	Male	Female	Total
Primary education (Level 1)	61.36	39.19	52.62
Lower secondary education (Level 2)	60.53	52.67	56.76
Upper secondary, basic (Level 3)	61.91	49.66	54.92
Upper secondary, final year (Level 4)	81.69	78.15	80.16
Post-secondary non-tertiary education (Level 5)	83.14	76.54	80.87
First stage of tertiary education, undergraduate (Level 6)	83.24	82.62	82.87
First stage of tertiary education, graduate (Level 7)	87.60	88.21	87.88
Second stage of tertiary education, postgraduate (Level 8)	91.66	89.89	91.00

Source: Author's calculation based on register-based database.

Table 3.8 provides the concrete estimates of employment rate by education for the total, the Males, and the Females, which are calculated by the number of people in each educational level who are either employed or self-employed (from Tables 3.5, 3.6, and 3.7) divided by the number in the corresponding category of the working age population (from Tables 3.2, 3.3, and 3.4). The results confirm the same conclusion as above-mentioned.

In addition, for each educational level, the employment rate is higher for the Males than that for the Females, except for the Level 7 where the employment rate for the

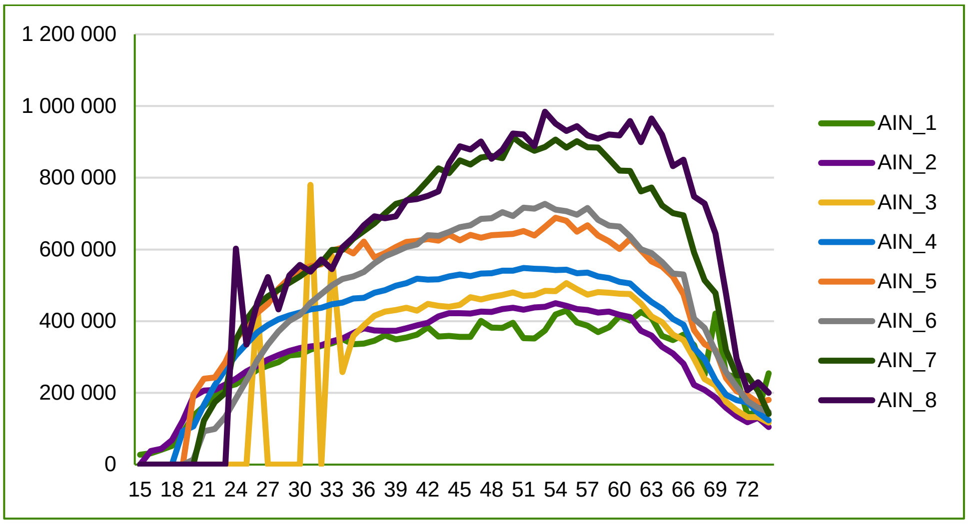
Males is slightly lower than that for the Females. Moreover, the difference of the employment rate between the Males and the Females, is in general small at the higher educational level, such as Level 6, Level 7, and Level 8.

3.4. Annual income

Annual income here refers to annual labour income which is derived from the register-based database where actual annual payment ('sumklonn') is given for those who are employed in the year. Due to data limitation, annual labour income, rather than labour compensation, is used to approximate the remuneration to labour services generated from the use of human capital.

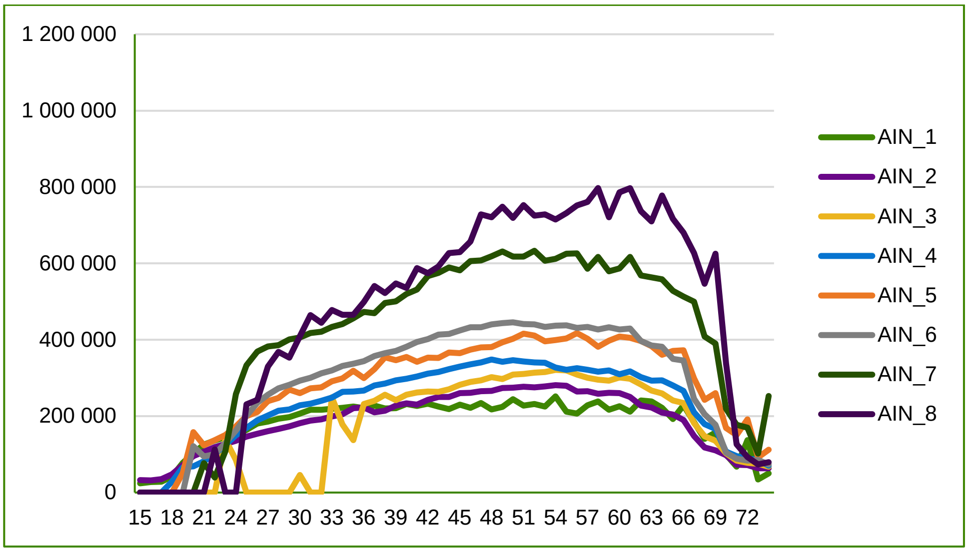
The annual income with certain age and education (AIN_{age}^{edu}) is defined as the average actual annual payment of all the employed (i.e. as employees) people within this specific age and education category.

Figure 3.4. Annual income by age and educational level in 2014 (Male, NOK)



Source: Author's own calculations.

Figure 3.5. Annual income by age and educational level in 2014 (Female, NOK)



Source: Author's own calculations.

Annual income for the self-employed people is assumed to be the same as that for the employed people, as well as for other people if employed, as long as all these people are of the same age, gender and educational level. This assumption is also made frequently by many other studies (e.g. Wei, 2004, 2007; Greaker, 2008), and is consistent with the assumption made in the labour accounts within the current Norwegian national accounts system.

The annual income is computed separately for the Males and the Females. The profile of calculated annual income by age and educational level in 2014 is displayed in Figure 3.4 for the Males and Figure 3.5 for the Females, respectively.

As shown, there are some jumps in the displayed curves, especially, at younger ages. There are several reasons; one is that sometimes there are no people at younger age having achieved higher (than normal) educational levels and at the same time being employed, then the number of observations in this category could be zero; another reason might be that there are sometimes very few people at some age having certain educational level (e.g. Level 3) and being also employed, such that the average actual annual payment calculated for these categories could be very sensitive to some value of outliers.

However, in general, the annual income is higher for the Males than for the Females, irrespective of educational levels. And the annual income can be considered to rise with age and then gradually decline (in part due to the existence of ‘cohort effect’), a pattern that holds almost for all educational levels.

Given gender, the annual income is normally higher for people with higher levels of educational attainment. The significant income gaps exist between those with Level 7 and Level 8 and those with other (lower) levels, which may imply that the returns to investments into Level 7 and Level 8 are considerably high.

3.5. Enrolment rate

The enrolment rate with certain age and education enrolling into another higher educational level ($ENR_{age}^{edu-\overline{edu}}$) is defined in this study as the number of people with this specific age and education (edu) who are studying in another higher educational level ($\overline{edu}$), divided by the total number of people within this specific age and education (edu) category, no matter whether they are studying or not.
As outlined in Section 2.3, the enrolment rate in this study is endogenously derived by the register-based database for all people of age 15 to 74. This is different from previous practices where the enrolment rate for people beyond certain age (a sometimes arbitrarily determined cut-off of upper bound after which further study is not allowed) is exogenously set equal to zero.

In order to calculate the enrolment rate from lower to higher educational level, the actual school enrolment path needs to be known. After checking the register-based database for the period of 2007-2014, a dominant pattern of school enrolment path appears. It is reported in Table 3.9, together with detailed information on school duration which is the normal years needed for completing a certain educational level.

Table 3.9. School enrolment path and duration (years) in Norway

Year	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
Level 1	3	-	-	-	-	-	-
Level 2	-	2	3	-	-	-	-
Level 3	-	-	1	-	-	-	-
Level 4	-	-	-	3	4	-	-
Level 5	-	-	-	-	1	-	-
Level 6	-	-	-	-	-	2	-
Level 7	-	-	-	-	-	-	3

Notes: ‘-’ stands for ‘Not allowed by assumption’.
Source: Author’s calculation based on register-based database.

Table 3.9 can be read like this. For people with education Level 1 already achieved, enrolment for further study can only be allowed to Level 2, and the school duration from Level 1 to Level 2 is 3 years. For people with education Level 2 already achieved, enrolment for further study can take place along two lines: one is from Level 2 to Level 3 with the school duration of 2 years, and the other is from Level 2 to Level 4 with the school duration of 3 years.

It is worth mentioning that several practical assumptions are made with Table 3.9, such as:

- Individuals can only enroll in a higher educational level than the one they have already completed;
- No further enrolment is allowed for people having already achieved the highest educational level (i.e. Level 8);
- No delaying, quitting or skipping is allowed during the whole period of studying in each level.

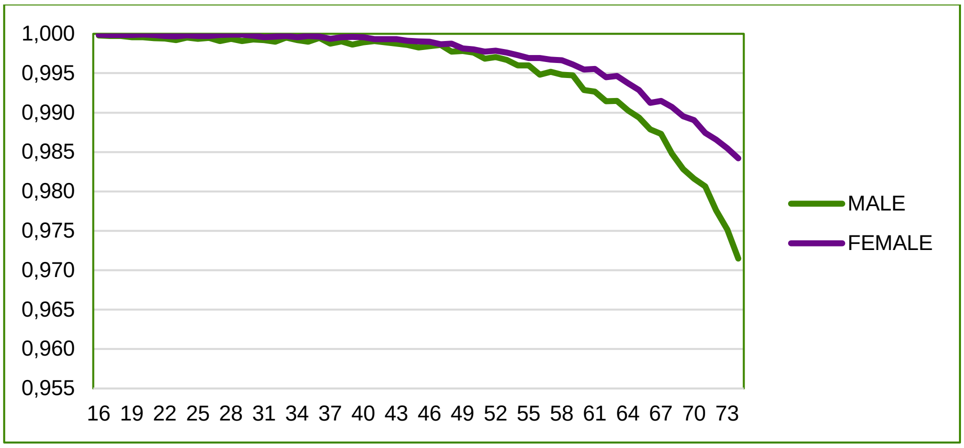
As mentioned before, people with education Level 0 (No education and pre-school education) have been subsumed within those with Level 1, that is the reason why education Level 0 does not appear in Table 3.8. However, since the share of people with Level 0 is quite small (0.3% of total working age population, or 0.1% of total employment population), the biases due to this treatment should not be significantly large.

3.6. Survival rate

So far, we have discussed a number of variables that are endogenously derived from the register-based database. However, for measuring human capital by using equation (1), it is necessary to have other variables/parameters that are drawn exogenously from other sources, such as the survival rate, annual real income growth rate, and real discount rate.

The survival rate (SUR_{age}) is the probability of surviving one year given that this individual is at the age of "age". The survival rate by age and gender is calculated as 1 minus the probability of death at the age of "age". The latter is drawn from the life tables for Norway, taken from the StatBank, an online statistics databank at Statistics Norway.

Figure 3.6. Survival rate by age and gender in 2014



Source: Derived from the life tables from StatBank at Statistics Norway.

There are some studies showing that people with higher educational attainment also have longer life expectancy and higher survival rate, attributed to a range of factors, such as having a healthier lifestyle (e.g. doing more exercise, having a healthier diet), having better working and living conditions, and having greater access to quality health-care (e.g. OECD, 2010).

Despite the evidences, it is difficult to find the relevant data on the extent to which higher educational attainment improves survival rate. Therefore, for human capital measurement, the survival rates for people with certain age and gender are often considered to be the same, regardless of their educational levels, although in some studies the survival rates differentiated by education are constructed for some age groups (e.g. Barro and Lee, 2013).

Figure 3.6 displays the survival rate by age for both the Males and the Females in Norway for 2014; both curves are typically concave. As shown, the survival rate declines with age, and the decline accelerates when people age, for both the Males and the Females. Overall, the Females have higher survival rate than the Males at each age.

3.7. Real income growth rate

When applying equation (1) for calculating the lifetime income, one of the two important parameters should be given, the first is the annual real growth rate of the labour income in the future (r), which is used for calculating the future income streams; and the second is the annual real discount rate (δ), which is used for calculating the present value of the future income streams.

Assuming a common Cobb-Douglas production function for the total economy as:

(3)
$$Y = AL^{\alpha}K^{\beta},$$

Where Y is the total production (e.g. GDP), A is multifactor productivity, L is labour input, K is capital input. Finally, α and β are the output elasticities of labour and capital, respectively. Then we have:

(4)
$$\frac{\partial Y}{\partial L} = A\alpha L^{\alpha-1}K^{\beta} = \alpha\frac{Y}{L},$$

which shown that the marginal product of labour ($\frac{\partial Y}{\partial L}$) is proportional to the labour productivity or the average product of labour ($\frac{Y}{L}$).

Because the marginal product of labour equals the real wage when the labour market is in equilibrium, then the labour productivity and the real wage are expected to grow at the same rate. Therefore, the real growth rate of labour productivity can serve as a reasonable approximate for the real growth rate of the labour income.

The estimated Norwegian annual real growth rate of labour productivity is 2.29%, which is a geometric mean across the period of 1970-2014[9] and is drawn from the StatBank at Statistics Norway. Therefore, we apply r = 2.29% to equation (1) for human capital measurement for 1997-2014.

3.8. Discount rate

When measuring human capital by applying equations (1) and (2), it is clear that a high annual real income growth rate (r) raises the present value of the future

[9] The arithmetic mean over the same period of 1970-2014 is 2.32% (see Table 09174 in Statbank at Statistics Norway).

incomes, resulting in higher estimates of human capital, the opposite is true for a high annual real discount rate (δ).

A number of studies applying the lifetime income approach for measuring human capital have found that the estimated stock value of human capital is sensitive to the choice of these two parameters, i.e. annual real income growth rate (r) and annual real discount rate (δ) (e.g. Wei, 2004; Gu and Wong, 2008; Liu and Greaker, 2009; Liu, 2011; World Bank, 2011).

Owing primarily to a lack of both theoretical and empirical evidences, some national (e.g. Ahlroth *et al*. (1997) for Sweden; Wei (2004) for Australia), as well as international studies (e.g. Liu, 2011, Hamilton and Liu, 2014) have simply chosen the same values of either one or both two parameters as used by the original Jorgenson and Fraumeni study for the United States.[10]

Literature review reveals that the annual real discount rate used in empirical studies can be as low as 3.5% in the case of Norway (Ervik *et al*., 2003; Liu and Greaker, 2009) and as high as 8.26% in the case of China (World Bank, 2011).

Within the World Bank's wealth accounting framework, a uniform discount rate of 4% is used which is derived from the Ramsey formula (World Bank, 2006, 2011). Strictly speaking, the discount rate is the social rate of return to investment, i.e., is a kind of social discount rate from a social planner's point of view, while the discount rate used for measuring human capital by using (1) and (2) is a long-term private return from an individual perspective (Fraumeni, 2011). The difference can be illustrated by the following example.

Consider an individual deciding to undertake formal education. Since the risk that he or she faces cannot be easily diversified, a relatively high rate of return may be needed to induce this person to remain in school. On the other hand, from the perspective of the society as a whole, investment in formal education is diversified across individuals and thus considerably less risky, meaning that future returns to this investment should be discounted at a lower rate (Abraham, 2010).

In som studies for Norway, Ervik *et al*. (2003) and Liu and Greaker (2009) applied an annual real discount rate of 3.5%, which was a real risk adjusted discount rate, and was in accordance to the recommendations for public cost-benefit analyses given in Norwegian Ministry of Finance (1997).

In some other studies, Norwegian Ministry of Finance (2000) and Greaker *et al*. (2005) used an expected annual real discount rate of 4% for national wealth accounting. Liu (2016) used the same discount rate of 4% for making estimate of the wealth of Norwegian raw oil and natural gas. The choice of 4% as real discount rate is consistent with that the annual expected long-term real rate of return to the Government Pension Fund Global (GPFG) was set as 4% by the Norwegian Ministry of Finance (2012).

In recognition that the decision of human capital investment mostly occurs at individual level, and the currently widely used 4% discount rate are set mostly for evaluating and managing public projects in Norway, we decide that for our purpose in this study, an annual real discount rate of 5% is applied. In addition, a sensitivity

[10] Annual real income growth rate of 1.32% and discount rate of 4.58% applied in Jorgenson and Fraumeni study were originally used by Jorgenson and Yun (1990) and Jorgenson and Fraumeni (1992a) in their estimations for the United States, and they correspond to their estimates of the annual growth rate of (Harrod neutral) productivity and of the long-run rate of return for the private sector of the economy, respectively.

analysis based on different (from 5%) values of real discount rates is also conducted.[11]

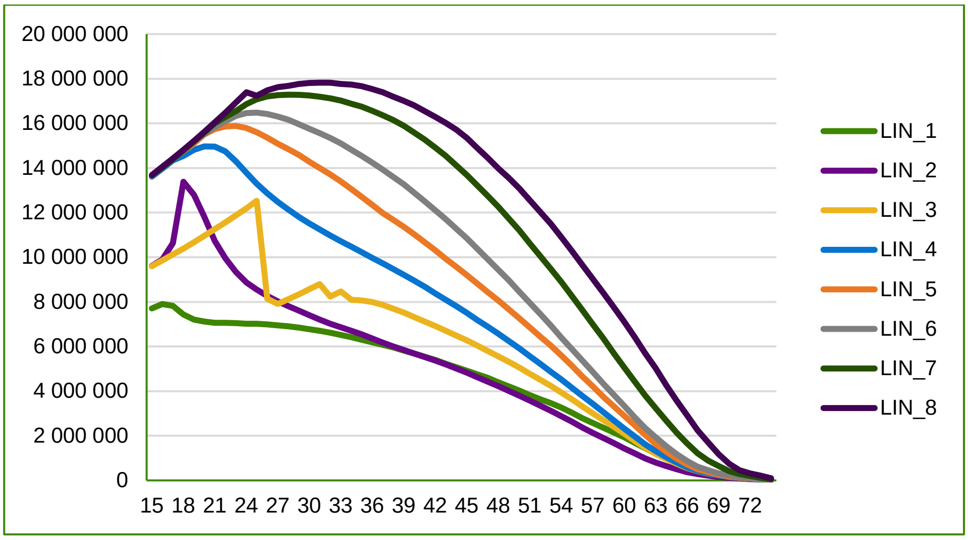
More discussions dwelling upon the choice of the two important parameters in general and the real discount rate in particular are beyond the scope of this paper. However, the issue could serve as an interesting topic for further research in the future.

4. Empirical results

4.1. Lifetime income

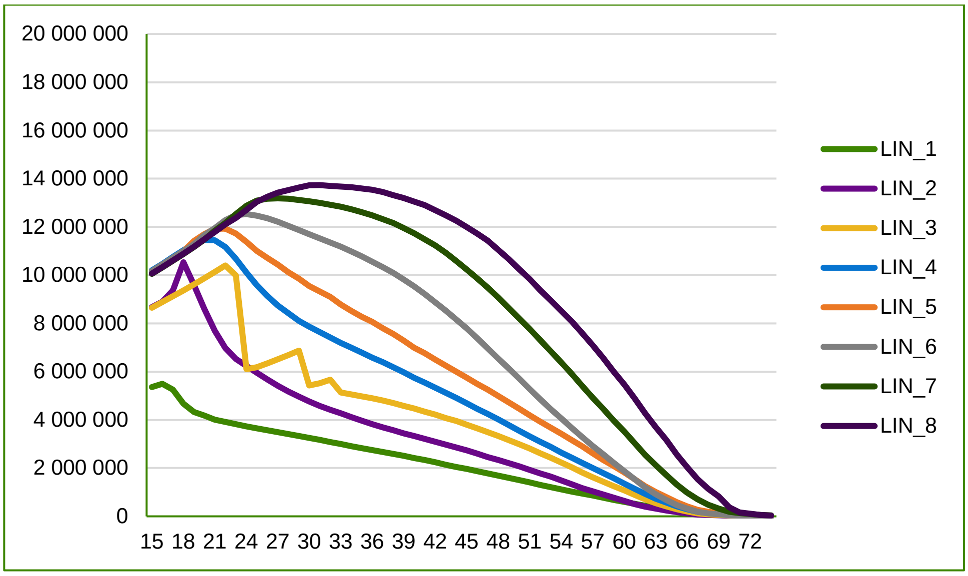
Given the annual real income growth rate of 2.29%, and the real discount rate of 5%, the lifetime income (LIN_{age}^{edu}) is calculated by following equation (1). Figure4.1 and Figure 4.2 display the profile of lifetime income by age and education in 2014 for the Males and the Females, respectively.

Figure 4.1. Lifetime income by age and educational level in 2014 (Male, NOK)



Source: Author's own calculations.

Figure 4.2. Lifetime income by age and educational level in 2014 (Female, NOK)



Source: Author's own calculations.

[11] As for the estimates and results from such a sensitivity analysis based on different (from 5%) values of annual real discount rates, please contact the author for detailed information.

As shown in both Figures, the lifetime incomes rise with age and then gradually decline, displaying typical concave curves, and this holds in general for all educational levels. The reason is that when one becomes one year old, his/her annual income generally increases, but at the same time, his/her remaining working years reduced with one year. The joint effect of the two opposite forces determines the shape of the lifetime incomes, and in particular, when the peak occurs.

The peak occurs at younger ages for the lifetime income than for annual income (see Figure 3.4 and Figure 3.5). Clearly, the lifetime incomes are higher for people with higher educational levels, and they are higher for the Males than for the Females, at all educational levels.

At any given value of annual real discount rate, the shape of the lifetime income curves critically depends on the age at which highest annual income enters the income streams of individuals' working life span. If annual income peaks at older ages, then lifetime labour income will peak at older ages as well.

Based on a sensitivity analysis by using different values of annual real discount rate, it demonstrates that the higher the real discount rate, the lower the values of future incomes, and hence the earlier the lifetime l income peaks.

4.2. Total and active human capital

With the calculated lifetime income ready for each representative individual with certain age, gender, and education, applying equation (2) generates the estimate of the stock value of human capital for this specific age/gender/education group. Summing up across all groups by age/gender/education yields the final estimate of the stock value of human capital for Norway.

Table 4.1. Total human capital by gender and educational level in 2014 (NOK in billions)

Educational level	Male	Female	Sum
Primary education (Level 1)	1 664 (6.0 %)	642 (2.3 %)	2 306 (8.3 %)
Lower secondary education (Level 2)	3 328 (12.0 %)	1 986 (7.1 %)	5315 (19.1 %)
Upper secondary, basic (Level 3)	399 (1.4 %)	257 (0.9 %)	657 (2.4 %)
Upper secondary, final year (Level 4)	4 896 (17.6 %)	2 743 (9.9 %)	7639 (27.5 %)
Post-secondary non-tertiary education (Level 5)	593 (2.1 %)	190 (0.7 %)	783 (2.8 %)
First stage of tertiary education, undergraduate (Level 6)	3 560 (12.8 %)	4 075 (14.6 %)	7634 (27.4 %)
First stage of tertiary education, graduate (Level 7)	1 803 (6.5 %)	1 333 (4.8 %)	3137 (11.3 %)
Second stage of tertiary education, postgraduate (Level 8)	229 (0.8 %)	119 (0.4 %)	347 (1.2 %)
Sum	16 472 (59.2 %)	11 346 (40.8 %)	27 818 (100 %)

Notes: Share in total human capital (from both the Males and the Females) in parentheses.
Source: Author's own calculations.

Table 4.1 provides the distribution by gender and education of the *total human capital* (for the total working age population) in 2014. As shown, the Males group with education Level 4 (Upper secondary, final year) has the largest share (17.6%) in the total human capital (summed over both the Males and the Females), and the Females group with education Level 6 (First stage of tertiary education, undergraduate) has the second largest share (14.6%).

Due in part to this, among all educational levels, those people (either male or female) with education Level 4 own the largest part (27.5%) of the total human capital, and those with education Level 6 own the second largest part (27.4%), which is only slightly lower than the first largest share.

Likewise, the distribution by gender and education of the *active human capital* (for the total employment population) in 2014 is provided in Table 4.2. By focusing only on the employed and self-employed people that comprise the total employment population as defined in this study, Table 4.2 shows that the Males group with education Level 4 and the Females group with education Level 6 are still of the first and the second largest share, i.e. 19.0% and 16.5%, respectively.

However, among all educational levels, those people (both male and female) with education Level 6 become the largest group (30.9%) of the total human capital, and those with education Level 4 becomes the second largest group (28.9%). In part, this is due to that people with education Level 6 has in general higher employment rate than those with education Level 4 (see subsection 3.3 and Table 3.2 and Table 3.5).

Table 4.2. Active human capital by gender and educational level in 2014 (NOK in billions)

Educational level	Male	Female	Sum
Primary education (Level 1)	958 (4.4 %)	212 (1.0 %)	1 170 (5.3 %)
Lower secondary education (Level 2)	2 059 (9.4 %)	1 144 (5.2 %)	3 203 (14.6 %)
Upper secondary, basic (Level 3)	317 (1.5 %)	194 (0.9 %)	511 (2.3 %)
Upper secondary, final year (Level 4)	4 148 (19.0 %)	2 173 (9.9 %)	6 321 (28.9 %)
Post-secondary non-tertiary education (Level 5)	528 (2.4 %)	159 (0.7 %)	687 (3.1 %)
First stage of tertiary education, undergraduate (Level 6)	3165 (14.5 %)	3 600 (16.5 %)	6 765 (30.9 %)
First stage of tertiary education, graduate (Level 7)	1 678 (7.7 %)	1 208 (5.5 %)	2 886 (13.2 %)
Second stage of tertiary education, postgraduate (Level 8)	215 (1.0 %)	108 (0.5 %)	323 (1.5 %)
Sum	13 069 (59.8 %)	8 797 (40.2 %)	21 866 (100 %)

Notes: Share in total human capital (from both the Males and the Females) in parentheses.
Source: Author's own calculations.

4.3. Active human capital by industry

Table 4.3 provides the distribution of active human capital by gender and industry in 2014. Note that such a distribution of active human capital should not be interpreted as human capital owned by different industries. Because human capital as embodied in an individual should be considered as being owned exclusively by him/herself (see Liu, 2015), rather than as being owned by the industry with which he/she is working.

For an individual working with an industry, he/she is never meant to sell him/herself because it is simply illegal in modern society nowadays, but rather, he/she is actually renting at a wage rate the labour services which come from the human capital embodied. Thus, the distribution as shown in Table 4.3 just reflects that how much active human capital are used, rather than owned, in each industry in current year, here in 2014.

The industries are classified by following the Norwegian standard industrial classification 2007 (SN2007), which is in accordance with the EU's standard NACE Rev.2. The industries are classified at the first level by sections, giving in total 21 industries (from Industry A to Industry U as shown in Table 4.3).
Since there are some people in the register-based database without specifying any industry they are working with, we define an 'unspecified industry' as a special group and denote it by X for these people as shown in the second to last row in Table 4.3.

Table 4.3. Active human capital by gender and industry in 2014 (NOK in billions)

Industry	Male	Female	Sum
A-Agriculture, forestry and fishing	389	93	482
B-Mining and quarrying	511	105	616
C-Manufacturing	1 449	323	1 772
D-Electricity, gas, steam and air conditioning supply	98	24	122
E-Water supply; sewage, waste management and remediation activities	86	16	102
F-Construction	1 723	111	1 833
G-Wholesale and retail trade; repair of motor vehicles and motorcycles	1 721	1 271	2 992
H-Transportation and storage	840	168	1 009
I-Accommodation and food service activities	391	410	800
J-Information and communication	700	212	912
K-Financial and insurance activities	241	145	386
L-Real estate activities	137	62	199
M-Professional, scientific and technical activities	848	458	1 306
N-Administrative and support service activities	789	378	1 167
O-Public administration and defence; compulsory social security	834	547	1 381
P-Education	767	1 015	1 783
Q-Human health and social work activities	1 054	2 983	4 038
R-Arts, entertainment and recreation	266	202	468
S-Other service activities	151	228	379
T-Activities of household as employers; undifferentiated goods- and services-producing activities of households for own account	1	1	2
U-Activities of extraterritorial organisations and bodies	1	1	2
X-Unspecified	73	44	117
Sum	13 069	8 797	21 866

Source: Author's own calculations.

As shown in the last column in Table 4.3, Industry Q (Human health and social work activities), Industry G (Wholesale and retail trade; repair of motor vehicles and motorcycles) and Industry F (Construction) are the first three industries where total active human capital (including active human capital used by both the Males and the Females) are most employed, ranked by descending order.

In terms of active human capital used by the Males, the first three largest industries are Industry F (Construction), Industry G (Wholesale and retail trade; repair of motor vehicles and motorcycles), and Industry C (Manufacturing); while for active human capital used by the Females, it is Industry Q (Human health and social work activities), Industry G (Wholesale and retail trade; repair of motor vehicles and motorcycles) and Industry P (Education) that are the first three largest industries. In fact, the Female active human capital in Industry Q is by far the largest across all industries, and regardless of the gender.

Table 4.4. Active human capital by education and industry in 2014 (Male, NOK in billions)

Industry	Level1	Level2	Level3	Level4	Level5	Level6	Level7	Level8	Sum
A	42	91	27	145	15	47	21	1	389
B	33	35	8	170	49	96	108	12	511
C	114	233	48	589	72	246	135	12	1 449
D	1	8	1	31	10	26	20	1	98
E	6	20	4	34	3	12	5	0	86
F	225	354	43	829	88	139	43	2	1 723
G	82	459	54	724	55	285	59	3	1 721
H	67	194	38	319	54	132	34	2	840
I	75	103	7	126	6	60	13	1	391
J	21	39	8	129	19	312	164	8	700
K	3	7	3	40	4	120	62	2	241
L	8	14	5	38	5	52	15	0	137
M	40	31	8	110	35	278	294	53	848
N	179	143	17	242	24	139	42	2	789
O	4	98	10	181	47	299	187	9	834
P	17	34	6	85	11	371	170	73	767
Q	23	128	18	226	18	394	223	25	1 054
R	12	40	5	75	6	93	33	3	266
S	7	17	4	37	4	45	36	2	151
T	0	0	0	0	0	0	0	0	1
U	0	0	0	0	0	0	0	0	1
X	2	9	3	19	3	20	12	4	73
Sum	958	2 059	317	4 148	528	3 165	1 678	215	13 069

Source: Author's own calculations.

By comparing the two columns of Male and Female in Table 4.3, it seems that in most of the industries, there are more human capital used by the Males than by the Females. Only 4 out of 21 industries have employed more human capital by the Females than by the Males, i.e. Industry I (Accommodation and food service activities), Industry P (Education), Industry Q (Human health and social work activities), and Industry S (Other service activities).

The distribution of active human capital by industry and educational level in 2014 is presented in Table 4.4 for the Males and Table 4.5 for the Females, respectively. As the last row of the two tables shows, the first three educational levels with largest share of human capital, regardless of industry, are Level 4, Level 6, and Level 2 for the Males; and Level 6, Level 4, and Level 7 for the Females, all ranked by descending order. Not surprising, all these observations are consistent with the results as shown in Table 4.2.

If taking industry dimension into account, Table 4.4 shows that for the Males, in 10 out of 21 industries Level 4 has the largest share of active human capital; and in 9 out of 21 industries, Level 6 has the largest share of active human capital.

Table 4.5. Active human capital by education and industry in 2014 (Female, NOK in billions)

Industry	Level1	Level2	Level3	Level4	Level5	Level6	Level7	Level8	Sum
A	6	18	4	29	2	26	8	0	93
B	2	4	1	16	3	34	41	3	105
C	14	49	10	97	10	93	47	4	323
D	0	1	1	5	1	10	6	0	24
E	0	2	1	4	1	5	4	0	16
F	5	17	4	34	4	34	12	0	111
G	33	371	29	497	29	262	49	2	1 271
H	6	29	7	61	6	48	11	0	168
I	41	131	5	137	6	75	13	1	410
J	3	11	2	35	5	108	46	2	212
K	1	4	4	28	4	75	27	0	145
L	2	6	2	14	2	30	6	0	62
M	7	18	6	62	12	173	158	23	458
N	37	62	8	111	9	116	34	2	378
O	2	42	11	75	13	223	174	6	547
P	8	39	11	105	7	592	214	40	1 015
Q	31	269	80	717	36	1542	289	18	2 983
R	5	30	2	45	3	82	33	2	202
S	6	35	4	92	5	55	30	1	228
T	0	0	0	0	0	0	0	0	1
U	0	0	0	0	0	0	0	0	1
X	3	4	2	8	1	16	8	2	44
Sum	212	1 144	194	2 173	159	3 600	1 208	108	8 797

Source: Author's own calculations.

As for the Females, Table 4.5 shows that in 7 out of 21 industries Level 4 has the largest share of active human capital; and in 13 out of 21 industries, Level 6 has the largest share of active human capital.

If focusing only on much higher educational levels, such as Level 7 and Level 8, there are four industries that have the largest share of active human capital compared to other industries, and in general for both the Males and the Females. They are Industry M (Professional, scientific and technical activities), Industry O (Public administration and defence; compulsory social security), Industry P (Education), and Industry Q (Human health and social work activities).

Note that the purpose for above discussions on the distribution of active human capital by industry, as well as by gender and/or by education is simply to show the possibility for compiling (human capital) asset accounts for institutional sectors or even for industries.

More important, the current method for measuring human capital does not, due to data limitation, treat separately industry and/or occupation as one important factor determining labour income, even if it ought to from a pure theoretical point of view. Therefore, incorporating the dimension of industry and/or occupation into human capital measurement could serve as an interesting topic for future research.

4.4. Human capital, fixed capital, and Oil and Gas wealth

Given the annual real income growth rate of 2.29%, and the real discount rate of 5%, the Norwegian *total human capital* (for the working age population) in total and by gender for the period of 2007-2014 are estimated in current prices. The results are presented in Table 4.6.

Table 4.6. Total human capital, fixed capital, and Oil & Gas wealth in Norway (NOK in billions, current prices), and the ratios among them, 2007-2014

Year	Male	Female	SUM	Fixed capital	Oil&Gas wealth	HC/FC	HC/OG
2007	11 054	7 371	18 425	6 024	5 385	3.06	3.42
2008	12 438	8 130	20 569	6 570	5 519	3.13	3.73
2009	13 033	8 804	21 837	6 959	5 456	3.14	4.00
2010	13 025	8 986	22 011	7 266	5 573	3.03	3.95
2011	13 813	9 459	23 272	7 775	5 655	2.99	4.11
2012	14 541	9 946	24 486	8 241	5 608	2.97	4.37
2013	15 335	10 547	25 882	8 711	5 585	2.97	4.63
2014	16 472	11 346	27 818	9 269	5 589	3.00	4.98

Source: Author's own calculations.

Likewise, the Norwegian *active human capital* (for the population of employment) in total and by gender for the same period 2007-2014 are calculated in current prices and presented in Table 4.7.

Table 4.7. Active human capital, fixed capital, and Oil & Gas wealth in Norway (NOK in billions, current prices), and the ratios among them, 2007-2014

Year	Male	Female	SUM	Fixed capital	Oil&Gas wealth	HC/FC	HC/OG
2007	9 020	5 812	14 832	6 024	5 385	2.46	2.75
2008	10 088	6 414	16 502	6 570	5 519	2.51	2.99
2009	10 256	6 806	17 062	6 959	5 456	2.45	3.13
2010	10 243	6 903	17 146	7 266	5 573	2.36	3.08
2011	10 994	7 361	18 355	7 775	5 655	2.36	3.25
2012	11 656	7 702	19 358	8 241	5 608	2.35	3.45
2013	12 269	8 155	20 424	8 711	5 585	2.34	3.66
2014	13 069	8 797	21 866	9 269	5 589	2.36	3.91

Source: Author's own calculations.

The time series of human capital estimates as shown in Table 4.6 and Table 4.7 indicate that both the *total* and *active* human capital, regardless of gender, had been steadily increasing over the observed period 2007-2014.

For the purpose of comparisons for those who are interested, the stock values of Norwegian fixed capital and oil and gas wealth in current prices over the same period 2007-2014 are also provided in Table 4.6 and Table 4.7. The time series of the stock value of fixed capital is directly extracted from Norwegian national accounts database, and that of Norwegian raw oil and natural gas wealth is derived based on the estimates from Liu (2016).

In the last two columns (Columns 'HC/FC' and 'HC/OG)') in Table 4.6 and Table 4.7, the ratios of human capital to fixed capital and to oil and gas wealth are presented. Roughly speaking, over the period 2007-2014, the Norwegian stock value of total human capital is about 3 times of that of fixed capital, and around 3.5 to 5 times of that of oil and gas wealth; while the Norwegian active human capital is close to 2.5 times of that of fixed capital, and around 3 to 4 times of that of oil and gas wealth.

5. Concluding remarks

Using the Norwegian register-based database as the primary data input, this paper outlines experimental measurement of human capital for Norway over the period 2007-2014, by means of the internationally recommended lifetime income approach.

The lifetime income approach as applied in this study, compared with those previously applied, has been updated in several aspects, including the detailed implementation methodology, practical assumptions, and choice of exogenous parameters.

To align human capital measures with the Norwegian national accounts as much as possible, a sub-population is separated from the whole working age population, and is defined as the population of employment, consisting of the employed and the self-employed. Because human capital embodied in the employment population is considered as being currently active in terms of being employed/used by industry in each year.

Updates made in this study are more reasonable than before. For instance, the previous arbitrary and sometimes unrealistic assumption has been dropped that people older than certain age are not allowed to take further formal education. And the two key parameters are chosen by taking into account both theoretical and empirical evidences.

Using 2014 as an example, the age profiles of annual labour income and lifetime income by education are shown, all being in line with the results that are found in other studies. It has been found that the employment rate is in general higher for people with higher education; when education is given, it is higher for the Males than for the Females.

Given the choice of annual real income growth rate of 2.3% and discount rate of 5% in this study, the total human capital (for the working age population) and the active human capital (for the employment population) are estimated. The estimates show that both total and active human capital are increasing, regardless of gender for Norway over the period 2007-2014.

In addition, the estimated stock values of both total and active human capital are several times larger than that of either fixed capital or oil and gas wealth in Norway for the period 2007-2014, which supports the view that Norway is rich not only in natural resources, but also in human capital, and the latter is by far the most important component in the total Norwegian national wealth.

For possible productivity analysis, the distribution of active human capital by industry is presented, which indicates that most of active human capital are used in such industries as human health and social work activities; wholesale and retail trade as well as repair of motor vehicles and motorcycles; and construction.

If gender is taken into consideration, it seems that active human capital from the Males is mostly used in industries of both goods production (such as construction and manufacturing) and services providing; while that from the Females is mostly used in only services providing industries. In most of the industries, there are more active human capital used by the Males than by the Females, possibly due to that both the employment and the lifetime income are in general higher for the Males than for the Females in these industries.

If education is also taken into consideration, and by only focusing on Level 7 and Level 8, it shows that four industries have the largest share of active human capital. They are Industry M (Professional, scientific and technical activities), Industry O (Public administration and defence; compulsory social security), Industry P (Education), and Industry Q (Human health and social work activities), all being services providing industries.

From 2015 onwards, the Norwegian register-based database will use new data sources by following a new data reporting arrangement (‘A-ordning’ in Norwegian), the corresponding database used for human capital measurement will, therefore, be updated as well in the future.

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Statistics Norway

Postal address:
PO Box 8131 Dept
NO-0033 Oslo

Office address:
Akersveien 26, Oslo
Oterveien 23, Kongsvinger

E-mail: ssb@ssb.no
Internet: www.ssb.no
Telephone: + 47 62 88 50 00

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