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Discussion Paper

Human capital in the Netherlands

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1. Introduction

As the global economy becomes increasingly knowledge intensive, national economies need to raise the knowledge levels of their population. The knowledge of a population can be considered as a capital good, which, just like conventional capital (e.g. physical infrastructure), has to be produced and maintained.

Modern economic theorists and politicians are very interested in measuring how investment in human capital contribute to economic growth and sustainable development. In their view, human capital is of vital importance. For instance, in the capital theory of sustainable development human capital is part of the national capital stock or wealth. This wealth consists of various types of capital: physical capital, natural capital, financial capital, human and other knowledge capital, and social capital. All these types of capital make up the wealth of a society to develop in a sustainable way, not only 'here and now', but also 'elsewhere and later'. This theory supposes that an economy is only on a sustainable growth path if the volume of capital per capita increases, or at least does not decrease.

In the current system of national accounts (SNA 2008), however, human capital does not fall within the capital boundary. The SNA considers education expenditures as consumption, and other types of investment in human capital (e.g. work experience and health improvement) are not taken into account at all. Human capital does not fall within the capital boundary of the SNA because of the on-going discussion about how to define and value human capital. But even if there was consensus on this issue , various conceptual and methodological problems would still have to be solved. Nevertheless, the SNA encourages research on measuring human capital as a capital good, possibly in a satellite account.

Recently, there has been a renewed international interest in the subject of human capital. This must be considered against the background of the discussion on measurement 'beyond gross domestic product'. There is an urgent feeling that statistical measures should be developed which complement gross domestic product (GDP). Although GDP is an important indicator for the economic welfare of a country, it does not cover all aspects of welfare in a broad sense, such as feeling safe, depletion of natural resources and leisure activities. The discussion on broad welfare focuses on how to measure these aspects. It has led to a number of influential reports, among which the Brundtland report and the report by the commission Stiglitz, Sen and Fitoussi (see Smits and Hoekstra, 2011).

Although the focus is still on indicators, monetary measurement of human capital is receiving more and more attention. The advantage of such a monetary measure is that it can be directly linked to GDP. In June 2011, the UN Economic Commission for Europe / Conference of European Statisticians (UN ECE/CES), a meeting of the European organisation of the UN, dedicated a one-day workshop to 'human capital' and how to measure it.[1] A number of foreign statistical institutes have already developed concrete monetary measures of national human

[1] See www.unece.org/stats/documents/2011.06.ces.html.

capital stocks.[2] An OECD Task Force on Human Capital Accounts published a report with monetary measures of human capital for 15 countries on the basis of OECD data (Liu, 2011).[3]

Recently, Statistics Netherlands has also estimated the size and change of human capital in the Netherlands. This report is the final result of a project within the Sustainability research programme at Statistics Netherlands. The report presents experimental estimations of the level and growth of human capital in the period 1999-2009, and discusses the plausibility of these estimates based on the lifetime income approach.[4] The figures presented in this report are not official statistics of Statistics Netherlands, and not published as such.[5] The estimates are still under investigation and have a highly explorative character, and should therefore be treated with caution when drawing conclusions based on the current research results. The results just give an indication of the sources of growth of human capital, investment in human capital, and how the estimate of human capital in the Netherlands compares to other types of capital and GDP, and to other countries. The experimental character is also the reason for the discussion of the results in Section 4. An elaborated version of this report (with details on the data) is published as an internal report (Rensman, 2013a).

The report starts with a brief discussion in Section 2 on the concept and importance of human capital and how it can be measured within the context of the system of national accounts. This report applies the lifetime income approach. Lifetime income, or human capital per capita, is measured as the discounted future labour income flows of a representative individual. We apply an empirical variant of this method, which is now commonly used internationally. Section 2 goes on to describe the data sources used and the construction of the human capital database, and concludes with the resulting age-education and age-income profiles of the Dutch population, and the age-lifetime income profiles. Section 3 presents the estimates on the human capital stock and investment in the Netherlands in the period 1999-2009. Human capital is compared to other types of capital in the economy, to GDP and to human capital in other countries. In Section 4 we discuss the plausibility of the estimates of human capital. To what extent do the estimates change if assumptions change? How do the results of alternative models compare to those in Section 3? How much human capital is latent due to not – or an unwillingness to working full-time? Also, we consider the linking of monetary measures of human capital to the national accounts. Section 5 presents the conclusions of the study.

[2] Country studies with estimates of human capital stocks are Christian (2011) on the USA, Ahlroth et al. (1997) on Sweden, Liu and Greaker (2009) on Norway, Kokkinen (2010) on Finland, Jones and Fender (2011) on the UK, Wei (2009) on Australia, Gu and Wong (2010) on Canada, Le et al. (2006) on New-Zealand, Li et al. (2012) on China.
[3] The 15 countries are Australia, Canada, Denmark, France, Israel, Italia, Korea, Netherlands, New-Zealand, Norway, Poland, Romania, Spain, the UK and the USA.
[4] With thanks to many colleagues of Statistics Netherlands for their comments and help.
[5] A brief version of Section 3 has been published in De Nederlandse Economie 2011 (Rensman, 2012).

2. Measurement

We start with a brief theoretical discussion on the concept of human capital in Section 2.1. Section 2.2 describes the lifetime income method to measure the stock of human capital, and the decomposition method to calculate investment in human capital. In Section 2.3 we describe our data, the education and income profiles of our population, and estimated lifetime incomes per capita.

2.1 Human capital as an investment good

What is human capital? There are many definitions, but one which fits with the theory of Schultz (1961) and Becker (1964) is 'the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being' (OECD, 2007, p.29). This human capital is formed by education and training, but this can be extended to other factors which contribute to the formation of human capital, such as investments in health improvement.[6] Economic theory and policy on growth and sustainability assign a key role to human capital investments. For instance, in the theory of sustainable development human capital is part of the national capital or wealth of an economy. In order to maintain a sustainable growth path, real capital per capita needs to remain stable or to rise, and thus should not decline.

However the SNA 2008 does not account for human capital as an investment good. The SNA even considers education expenditures just as consumption (in theory being one of the drivers in human capital investments). Other types of 'investments', such as work experience, are not considered at all. The SNA nevertheless encourages research on human capital, including investments. This requires valuation of human capital in monetary terms. Then it might be possible to construct a balance sheet or satellite account. The most well-known methods to generate monetary measures of human capital are the cost approach and the income approach. These methods aim to overcome the problem of lack of market information on price and volume. The income method apparently fits best with economic theory on human capital and is the most feasible method regarding the available data. Therefore the income method is the preferred approach in various countries and international organisations. The current report also applies the income method to value human capital. Below we describe the income method and its application more into detail.

2.2 Calculating stock and investment

2.2.1 Stock: the lifetime income method

Jorgenson and Fraumeni (1989, 1992a, 1992b) developed a method to measure the monetary value of the human capital stock. This method calculates an individual's human capital (or 'lifetime income') as the sum of his or her current annual labour income and the discounted value of all expected future incomes that he or she generates in the labour market during the rest of his or her working life. The labour incomes are a valuation of investments in human capital by means of education. If an individual achieves a higher education level, the expected income increases and therefore also his or her human capital. Other types of investment in human capital (e.g., working experience and on-the-job training) are not taken into account in

[6] Appendix A lists the main factors driving human capital formation.

this model (see also Table A.1 in Appendix A). The total human capital stock of a country is calculated as the sum of the lifetime incomes of all individuals in the population.

Formally, one calculates the lifetime income of a representative individual by sex (*s*), education level (*e*) and age (*a*). A straightforward algorithm is presented in Equation (2.1). The lifetime income of an individual is equal to the current income plus the present value of the lifetime income in the next period (applying a survival rate, real income growth and discounting). The enrolment rate represents the probability that the individual has a higher education level ($\bar{e}>e$) in the next period (here: next year). The calculations with this algorithm are backwards recursive, starting with the oldest individuals with the highest education level in the population.

$$(2.1) \qquad h_{s,e,a} = y_{s,e,a} + s_{s,e,a+1}\left\{ enr_{s,\bar{e},a}\; h_{s,\bar{e},a+1} + \left(1 - enr_{s,\bar{e},a}\right) h_{s,\bar{e},a+1} \right\} \frac{\left(1+g\right)}{\left(1+r\right)}$$

where

h	= labour income per capita during rest of working life of representative individual
y	= average current labour income
enr	= enrolment rate at education level ($\bar{e}$) higher than (*e*)
s	= probability for individual aged (*a*) to survive to age (*a+1*)
g	= real income growth rate
r	= real discount rate.

The algorithm in Equation (2.1) knows different empirical applications, depending on the availability of data and assumptions. The common method applies different algorithms to different 'stages of life'. Jorgenson and Fraumeni (1992b) distinguished five stages in the life cycle for individuals in the US: 0-4 years (no school/no work); 5-15 years (school); 16-34 years (school/work); 35-75 years (work only) and 75+ (retirement). In recent research studies, human capital is usually calculated only for the working-age population, i.e. the population in the stages 'school/work' and 'work only'. There is no international consensus yet on the measurement of human capital of children and the elderly.[7] Moreover, the labour market dynamics and human capital related to the working-age stages has a direct relationship with the productive capacity of a national economy. Note that all individuals inside the labour force and outside the labour force are attached the same level of human capital.

The availability of data highly determines the human capital calculations. Due to the lack of data on individuals (micro-data) in many countries, calculations usually rely on data from labour force surveys and on categorical data (such as wage data by age group). Further, the measurement of education is usually restricted to general education financed by government. Other forms of education are not taken into account, as is mentioned above. The age separating the stages 'school/work' and 'work only' ranges between 34 and 40 years, depending on the availability of data on enrolment in general education in the country under consideration. Finally, the retirement age differs across countries. In the Netherlands, the working-age population is the population aged 15-64 years.[8] By restricting the calculations to general education and the working-age population, we measure a 'lower limit' of the value of the human capital stock of a national economy.

[7] Also foreigners working in the country under consideration are usually not taken into account.
[8] The Dutch retirement age is shifting to 67 years in the near future, and thereafter increases with life expectancy.

Equations (2.2) and (2.3) present the algorithms for the two stages of life for individuals in the working-age population (cf. Fraumeni, 2009). For the moment being, we arbitrarily fix the age separating the two stages at 40. In Equation (2.2) the lifetime income of a representative individual in the group (*e,a*) [9] is equal to the sum of his or her current labour income (adjusted for the probability for work, or the employment rate) and the present value of the lifetime income in the next period (adjusted for the survival rate, income growth rate and discount rate).

Working (age group 40-64), not studying

$$(2.2) \qquad LIN_{e,a} = EMR_{e,a}\ AIN_{e,a} + SUR_{a+1}\ LIN_{e,a+1}\ (1+g)/(1+r)$$

Studying-and-working (age group 15-40)

$$(2.3) \qquad LIN_{e,a} = EMR_{e,a}\ AIN_{e,a} + \left\{1-\sum_{\bar{e}} ENR_{\bar{e},a}\right\}\left(SUR_{a+1}\ LIN_{e,a+1}\ (1+g)/(1+r)\right) + \left\{\sum_{\bar{e}} ENR_{\bar{e},a}\right\}\left\{\left(\sum^{T} SUR_{a+t}\ LIN_{\bar{e},a+t}\ [(1+g)/(1+r)]^{t}\right)/T\right\}$$

where

LIN (e,a)	= lifetime income of representative individual aged (*a*) and education level (*e*)
AIN (e,a)	= current annual labour income
EMR (e,a)	= employment rate
SUR (a+1)	= survival rate
ENR (ē,a)	= enrollment rate at study level (*ē*)
T	= study duration to qualify for education level (*ē*)
t	= year of study
g	= real growth rate of labour income
r	= discount rate.

In Equation (2.3) the lifetime income is the sum of current labour income and the present value of the lifetime income in the next period. The latter is calculated as the sum of the second and third term on the right hand side of Equation (2.3), i.e. the expected value of incomes resulting from the probability for studying, or the enrolment rate.[10] The enrolment rate is the number of students studying at level (*ē*) divided by the total.

Equation (2.3) is the empirical counterpart of Equation (2.1). In practice, study duration is usually longer than one period, or year. This can be handled in different ways, depending on data availability and assumptions. In Equation (2.3), an 'average' of lifetime incomes is calculated, i.e., the sum of present values of incomes during study is divided by the study duration (*T*). Here we make important assumptions: there is no drop out or delay in study, students are equally distributed across the study years, and students with level (*e*) can only study at a higher level (*ē*>*e*).

[9] For convenience we suppress the subscript for sex (*s*).

[10] There is a probability $\{1 - \sum_{\bar{e}} ENR_{(\bar{e},a)}\}$ to continue working in the next period at the same education level (*e*) and consequently to earn the present value of a future lifetime income $\{SUR_{(a+1)}\ LIN_{(e,a+1)}\ (1+g)/(1+r)\}$, and a probability $\{\sum_{\bar{e}} ENR_{(\bar{e},a)}\}$ to follow a study to qualify for education level (*ē*), where one may earn the present value of future income $\{ [\sum^{T} SUR_{(a+t)}\ LIN_{(\bar{e},a+t)}\ ((1+g)/(1+r))^{t}] / T\}$ if level (*ē*) is achieved.

The calculations are backwards recursive. The algorithm for 'working only' (Equation 2.2) is calculated first, starting with the oldest age group with the highest education level. We assume that pensioners (aged 65 years and older) have a lifetime labour income of zero. Then the lifetime income of an individual aged 64 and education level (*e*) is exactly equal to his or her current labour income. For a 63-years old individual in the same group (*a,e*), this amount is applied as his or her expected lifetime income at age a+1 (=64), multiplied by the probability that he or she will not achieve a higher education level in that next period. But if he or she did achieve a higher education level ($\bar{e}$), he or she would earn the lifetime income of an individual aged 64 and with education level ($\bar{e}$). So this latter income functions as the expected lifetime income for the 63-years old individual, multiplied by the probability of achieving education level ($\bar{e}$) in the next period. This lifetime income of the 63-years old individual is in turn used in the calculation of the lifetime income of a 62-years old individual. In this way we calculate further backwards for younger individuals.

The total national human capital stock is calculated as the sum of human capital of all individuals (see Equation 2.4). The lifetime income of a representative individual in a group (*e,a*) is attached to all individuals in this group (Equation 2.4). Then the individual human capital stocks are added up across all groups.

$$(2.4) \qquad HC = \sum_a \sum_e LIN_{e,a} \times N_{e,a}$$

where

HC	= national human capital stock
N (e,a)	= number of persons in group (*e,a*)
LIN (e,a)	= lifetime income in group (*e,a*) of representative individual.

2.2.2 Investment: a decomposition method

Periodic changes in the national human capital stock are the result of the sum of gross investment, depreciation and revaluation. Gross investment is the sum of changes in lifetime incomes due to education, lifetime incomes for individuals reaching working-age (15), and immigration to the Netherlands. Depreciation is the sum of negative changes in lifetime incomes due to aging of the working-age population (with decreasing working life spans), and lifetime incomes of individuals who quit the working-age population because they retire, die or emigrate. Revaluation is the sum of changes in lifetime incomes (or 'price') between two subsequent periods for individuals with a given set of characteristics (*s,e,a*). The value of revaluations is mainly determined by short run changes in the value of human capital which have little to do with changes in embodied knowledge. The short run changes are the result of economic and institutional fluctuations on the labour market.

We apply a mathematical decomposition as proposed by Gu and Wong (2010). We emphasize this is a top-down approach, whereas it is preferable to measure the components directly with data.[11] The mathematical decomposition nevertheless gives a quick but sound indication of the contribution of each component to total change in the human capital stock. Gu and Wong (2010) supposed that the change of the human capital stock between periods t-1 and t can be decomposed to three components as follows:

[11] Wei (2008) constructed figures for Australia on the basis of direct measures of the components.

$$(2.5)\quad HC^{t}-HC^{t-1}=\sum_{s,e,a}h_{s,e,a}^{t}N_{s,e,a}^{t}-\sum_{s,e,a}h_{s,e,a}^{t-1}N_{s,e,a}^{t-1}$$
$$=\sum_{s,e,a}h_{s,e,a}^{t}N_{s,e,a}^{t}-\sum_{s,e,a}h_{s,e,a}^{t}N_{s,e,a}^{t-1}+\sum_{s,e,a}\left(h_{s,e,a}^{t}-h_{s,e,a}^{t-1}\right)N_{s,e,a}^{t-1}$$
$$=\left(\sum_{s,e,a}h_{s,e,a}^{t}N_{s,e,a}^{t}-\sum_{s,e,a}h_{s,e,a+1}^{t}sur_{a,a+1}^{t-1}N_{s,e,a}^{t-1}\right)$$
$$-\left(\sum_{s,e,a}h_{s,e,a}^{t}N_{s,e,a}^{t-1}-\sum_{s,e,a}h_{s,e,a+1}^{t}sur_{a,a+1}^{t-1}N_{s,e,a}^{t-1}\right)$$
$$+\sum_{s,e,a}\left(h_{s,e,a}^{t}-h_{s,e,a}^{t-1}\right)N_{s,e,a}^{t-1}$$

where

HC = national human capital stock
N = number of individuals
sur = survival rate
h = human capital per capita or lifetime income.

The first term in the last expression is the gross investment in human capital, the second one is depreciation, and the third term is revaluation.

Gross investment can be decomposed further into two components: the lifetime income following from the increase of the population with those entering the population when they reach working-age (15 years of age), and the increase due to gross investment in education and immigration:

$$(2.6)\quad \sum_{s,e,a}h_{s,e,a}^{t}N_{s,e,a}^{t}-\sum_{s,e,a}h_{s,e,a+1}^{t}sur_{a,a+1}^{t-1}N_{s,e,a}^{t-1}=$$
$$\sum_{s,e,a\subset\{15\}}h_{s,e,a}^{t}N_{s,e,a}^{t}+\sum_{s,e,a\not\subset\{15\}}h_{s,e,a}^{t}\left(N_{s,e,a}^{t}-sur_{a-1,a}^{t-1}N_{s,e,a-1}^{t-1}\right)$$

Depreciation can be decomposed into changes in lifetime incomes due to aging of the population, and individuals quitting the population because of retirement, death or emigration:

$$(2.7)\quad \sum_{s,e,a}h_{s,e,a}^{t}N_{s,e,a}^{t-1}-\sum_{s,e,a}h_{s,e,a+1}^{t}sur_{a,a+1}^{t-1}N_{s,e,a}^{t-1}=$$
$$\sum_{s,e,a}\left(h_{s,e,a}^{t}-h_{s,e,a+1}^{t}\right)sur_{a,a+1}^{t-1}N_{s,e,a}^{t-1}+\sum_{s,e,a}h_{s,e,a}^{t}\left(N_{s,e,a}^{t-1}-sur_{a,a+1}^{t-1}N_{s,e,a-1}^{t-1}\right)$$

We note that the changes in lifetime incomes due to immigration are not decomposed separately from those due to gross investment in education. The same applies for depreciation because of retirement, emigration and death. An important methodological problem is that earnings forgone due to studying at school are not modelled. These earnings forgone are now implicitly included in gross investment, while they actually should be part of depreciation.

2.3 Data, population and lifetime incomes

2.3.1 Data

In order to calculate lifetime incomes according to Equations (2.2) and (2.3), we need data on the number of persons, average annual labour incomes, employment rates, enrolment rates, durations of study programmes, survival rates, and a real income growth rate and discount rate. Some of these variables should be broken down by sex, age, and/or education level. In contrast to various other countries, we have micro-data to our disposal.[12] Those data come from the Social Statistics Database (SSD), a unique system including more than 50 registers and a number of surveys of Statistics Netherlands. Our data from the SSD comprise the Dutch working-age population, enrolment in education, annual wage incomes, and a number of variables with which we calculated employment rates. Our time period covers the statistical years 1999-2009.[13]

The SSD data were processed further before they were applied to calculate lifetime incomes. First, the education level is unknown for many individuals recorded in the SSD (about 60% of the registered population in 2009), so weighting was necessary. Second, we had to define employment based on SSD data, some further quantitative information and assumptions.[14] Third, we calculated total labour compensation for employees and the self-employed on the basis of the fiscal wage incomes of employees from the SSD and some other quantitative information.

Finally, we categorized education data into six classes at 2 digit SOI level,[15] and made assumptions on the average study duration needed to achieve a higher education level (see Table 2.1). Further we supposed that an individual may study at the most two levels higher than his or her current education level (*e*). Hence we calculated two enrolment rates, one for (*e+1*) and one for (*e+2*), with associated study durations. For instance, an individual with education level Middle B may study to qualify for High A, or he/she skips High A and goes directly for High B. In order to graduate for High A, he or she has to study 2 years, and for High B 5 years (proxied by 2 years High A + 3 years High B).

One should note that the education classes of the higher educated (High A and High B) contain heterogeneous education programmes. International differences in human capital stocks are probably mainly the result of differences in the higher educated part of the population. Most individuals in the European Union graduated at least in secondary education. Also inter-temporal changes in the late 20th and early 21th century are mainly the consequence of the increase of the share of higher educated in the population. Wei (2008) therefore focuses on post-secondary education programmes, and considers all other individuals as a basic stock of human capital. Another data issue is that the Middle groups (A and B) comprise many people,

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[12] Labour Force Survey data are often applied by other countries. In future research, we might also apply the Dutch LFS, or EBB, and compare the results with those based on the micro-data in the current report. But micro-data are preferred as they provide detailed information. Application of LFS data inevitably leads to categorical data.

[13] There were a number of metadata changes in the SSD for the statistical years after 2009, which we leave for future research (see Appendix E).

[14] The Dutch LFS (or EBB) provides information on who is working or belongs to the labour force, and how many hours have been worked. The EBB data are integrated into the SSD only recently so we could not take them into account without further data research. In future research, the EBB data might be benchmarked to our data order to derive an improved measure of the size of the labour force and employment rate (see Appendix E).

[15] The SOI is the standard education classification by Statistics Netherlands, and comparable to the ISCED. We applied SOI 2006 (see http://www.cbs.nl/nl-NL/menu/methoden/classificaties/overzicht/soi/2006/ default.htm).

and that these groups comprise general education and vocational training. One might discuss whether we should separate general and vocational programmes, because human capital formation may not only be about increasing knowledge levels but also about matching of supply and demand on the labour market.

Table 2.1 Classification of education levels and study durations

Education level	SOI classification	Average study duration before achieving education level from previous level (assumption)
Low A	Up to SOI 32 (primary education, lower secondary professional education: vmbo bbl)	-
Low B	SOI 33 (lower general and professional secondary education: mavo, havo/vwo onderbouw, vbo, vmbo theoretical/mixed)	1 year from Low A to Low B
Middle A	SOI 41 and 42 (intermediate vocational education and higher general secondary education: mbo2-3, credits for havo/vwo, havo, vhbo)	1 year from Low B to Middle A
Middle B	SOI 43 (intermediate vocational education and pre-university education: mbo4, vwo, prop hbo/wo)	2 years from Middle A to Middle B
High A	SOI 51, 52 and 53 (higher vocational education: hbo, hbo-BA, kand/BA wo)	2 years from Middle B to High A
High B	SOI 60 and 70 (higher education: wo doct, wo and hbo MA, PhD, postdoct educ)	3 years from High A to High B

For each statistical year, we constructed a human capital database based on the SSD data. We aggregated the weighted records to 600 groups by sex, education level and age ($s \times e \times a = 2 \times 6 \times 50$), with variables such as the number of persons and average labour incomes by group. In practice, there is no data for a small number of groups. Those 'empty' groups are at both the left and right side of the age distribution. For example, there usually are no individuals aged 15 who have a PhD degree. We did not apply imputation to fill these empty groups.

We added survival rates by sex and age from Statline, the data bank of Statistics Netherlands. There were no survival rates by education level in standard format. This while it is known that the higher educated have higher survival rates. According to Bruggink (2010) higher educated individuals live nearly 7 years longer than the lower educated. This difference has not changed between 1997/2000 and 2005/2008.

The real income growth rate g is calculated as the average annual growth rate of real labour compensation per hour worked in the period 1969-2010, which is 1.63%. The data are from the Dutch Labour Accounts and the consumer price index. The discount rate r is fixed at 4.58%, the rate applied by Jorgenson and Fraumeni (1992a). This rate is based on the estimated rate of return on long-term investments in the private sector of the USA. These values of the income growth rate and discount rate are chosen from a number of possible alternative values in Appendix C. Section 4.1 discusses the sensitivity of the human capital estimates for a change in the values of the income growth rate or discount rate.

As we have data on individuals who may study at any age up to 64 years, we applied Equation (2.3) to all individuals. If in a certain group with age (*a*) the enrolment rate is zero (which is often the case for older age groups), the third term on the right hand side of Equation (2.3) is zero, and Equation (2.3) automatically turns into Equation (2.2).

2.3.2 Population profiles

Table 2.2 shows the distribution of the working-age population (aged 15 to 64) across individual characteristics (sex, age and education) for the selected years 1999 and 2009, and the average annual growth rates for each category in the period 1999-2009. The number of individuals in the working-age population rose from 10.8 to 11.1 million in this period.

The share of the labour force (and labour participation) increased from three-quarter to 80% of the total working-age population. The share of females did not change much, but there was more growth in the number of females than in that of males, and their share is only slightly lower than that of males. The shares of some age groups have changed in this short period of time. The share of the individuals aged 25-34 dropped from 23.1% to 17.9%, whereas that of the group aged 55-64 strongly increased from 14.8% to 19.4%. Ageing is clearly at hand, but there is also a delayed effect of the decrease in the number of births. A more positive indication for human capital development is that the average education level of the working-age population has increased steadily. The share of population with post-secondary vocational education rose from 12.4% to 15.3%, and that of those with post-secondary general education from 6.2% to 8.5%.

Table 2.2 Composition and growth working-age population, 1999-2009

	Share in population (%)		Average annual growth rate (%)
	1999	2009	1999-2009
Working-age population	100.0	100.0	0.33
... Labour force	76.8	79.7	0.70
... Non labour force	23.2	20.3	-0.99
Sex			
... Male	50.7	50.4	0.26
... Female	49.3	49.6	0.40
Age			
... 15-24	17.4	18.2	0.78
... 25-34	23.1	17.9	-2.22
... 35-44	23.5	22.3	-0.20
... 45-54	21.2	22.2	0.78
... 55-64	14.8	19.4	3.07
Education			
... Low A	15.3	13.4	-1.01
... Low B	25.2	20.1	-1.92
... Middle A	23.1	20.4	-0.90
... Middle B	17.9	22.4	2.54
... High A	12.4	15.3	2.44
... High B	6.2	8.5	3.44

Figures 2.1 and 2.2 show the age-education profiles of the male and female population in 2009 more into detail.[16] We observe that older individuals have, on average, a lower education level than the younger ones. This is particularly the case for females. The outliers for education level Low B around age 17 are natural. At this age, there are many pupils enrolled in secondary education. Figures 2.3 and 2.4 show the age-income profiles. Income is defined as the average labour compensation for working individuals. The labour compensation of females is significantly lower than that of males. This is largely because females often work part time. Further, we observe that a higher education level generally implies a higher labour compensation.[17]

2.3.3 Lifetime incomes

We applied Equation (2.3) to calculate the lifetime incomes or human capital per capita. Figures 2.5 and 2.6 present the resulting lifetime incomes (per capita) for males and females in 2009. The patterns are in line with those calculated for other countries.[18] We see that the peak in lifetime income comes at a younger age than the one for labour compensation (see Figures 2.3 and 2.4). Younger individuals have a longer expected working life span than older ones, so their lifetime income is higher. Further, if the peak in labour compensation comes at a later age, then also lifetime income peaks at a later age. Finally we observe that the higher the education level (and hence labour compensation), the higher lifetime income.

The patterns in Figures 2.5 and 2.6 shown raise some questions. Equation (2.3) predicts that investment in human capital by means of education raises lifetime income per capita. At a certain age the increase in lifetime income turns into a decrease due to the decrease in the working life span, and also because there is generally no investment via education any more at older ages. We observe this pattern in Figure 2.5 and 2.6 for the higher education levels (High A and B). But the patterns for the lower education levels (particularly Low A and B) are somewhat different. The lifetime income at these lower education levels decreases strongly up to a certain age to stabilize thereafter.

Causes may be found in three aspects. First, annual labour incomes are actually the result of a multiple of factors, among which investments in human capital by means of education and working experience. Increasing working experience may offset a low expected lifetime income based on low education levels. Also there may be institutional factors, such as collective agreements on minimum wages. Second, the data themselves may affect patterns. The data are not broken down into the type of occupation or economic sector.

Third, there may be also methodological problems. At a young age, the probability of enrolling into education at a higher level is relatively large. This is taken into account in the lifetime income of lowly educated youngsters. If they grow older, their probability to study strongly decreases and therefore also their lifetime income. Further, there is the issue to what extent the lifetime income method implicitly takes future education into account. In the empirical variant applied, any individual who pursues an education programme is supposed to earn the lifetime income of an individual with higher education level, while the student has not finished his/her education programme yet (see the third term of Equation 2.3). Probably the lifetime

[16] If we would add up all education levels by age, then we would end with a bell curve.

[17] A final observation is the volatility in the income data, particularly at higher education levels. This raises the issue of desirability of smoothing of the actual data.

[18] See, for instance, Liu (2011), Liu and Greaker (2009) and Wei (2004a).

income during study should be measured differently, e.g. by averaging the lifetime incomes at education level (*e*) and (*e+1*) or (*e+2*), with weights depending on the individual's progress in the education programme.[19]

Figure 2.1 Age-education profile males by education level, 2009

number (× 1000)

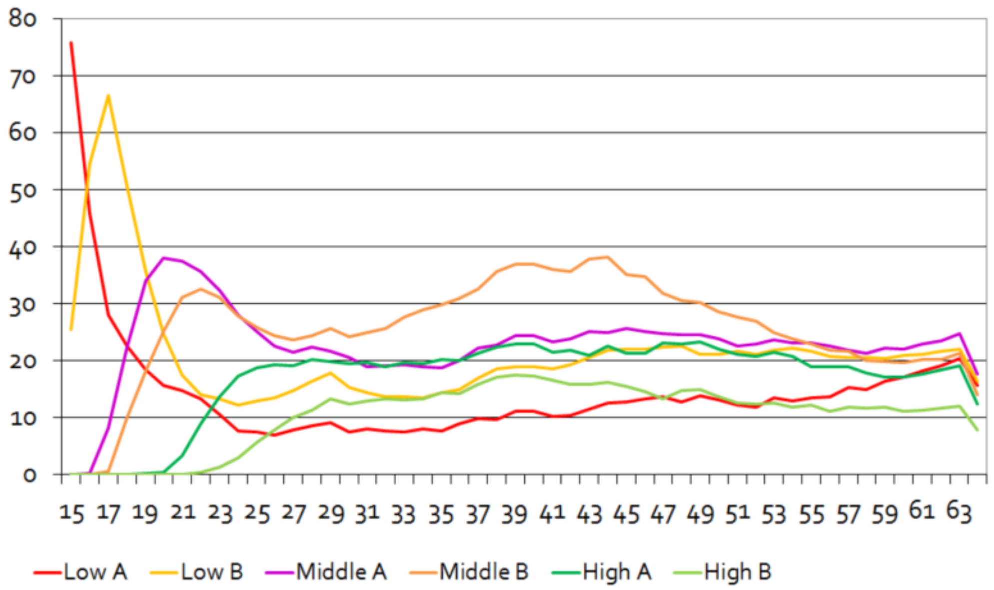
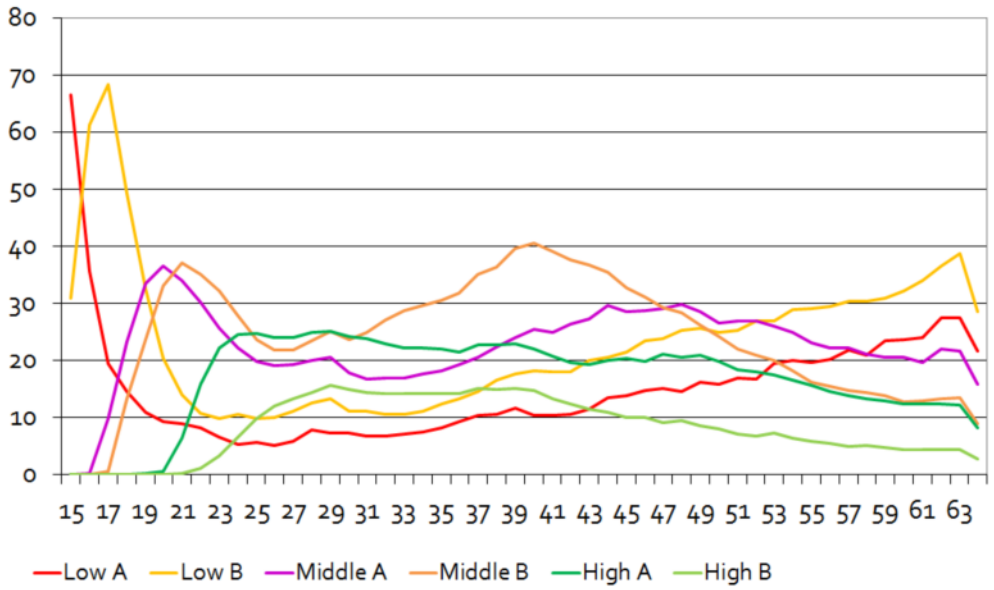


Figure 2.2 Age-education profile females by education level, 2009

number (× 1000)



[19] In an alternative empirical model described in Section 4.3, incomes during study are average part time earnings of students, which are substantially lower.

Figure 2.3 Age-income profile males by education level, 2009

euro (× 1000)

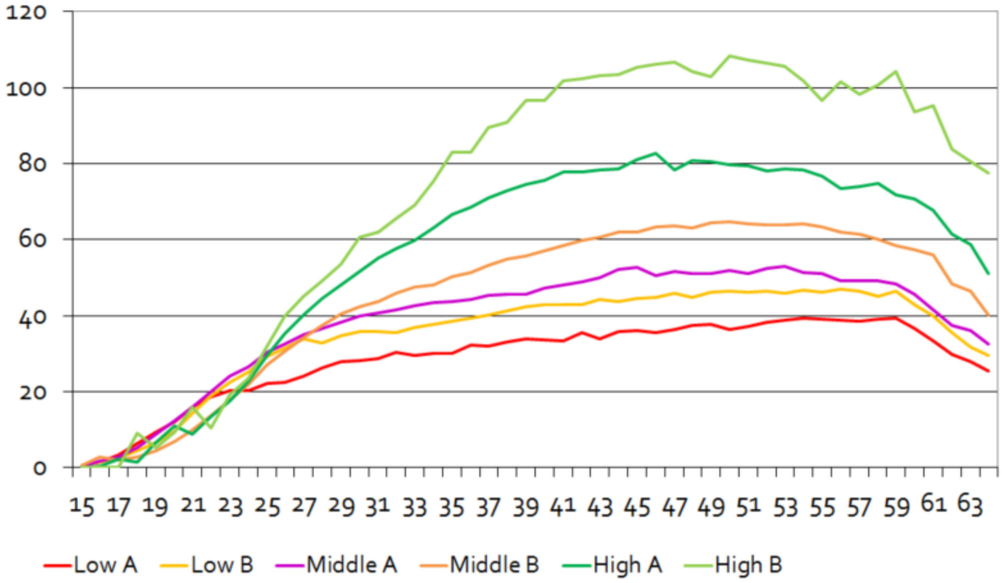


Figure 2.4 Age-income profile females by education level, 2009

euro (× 1000)

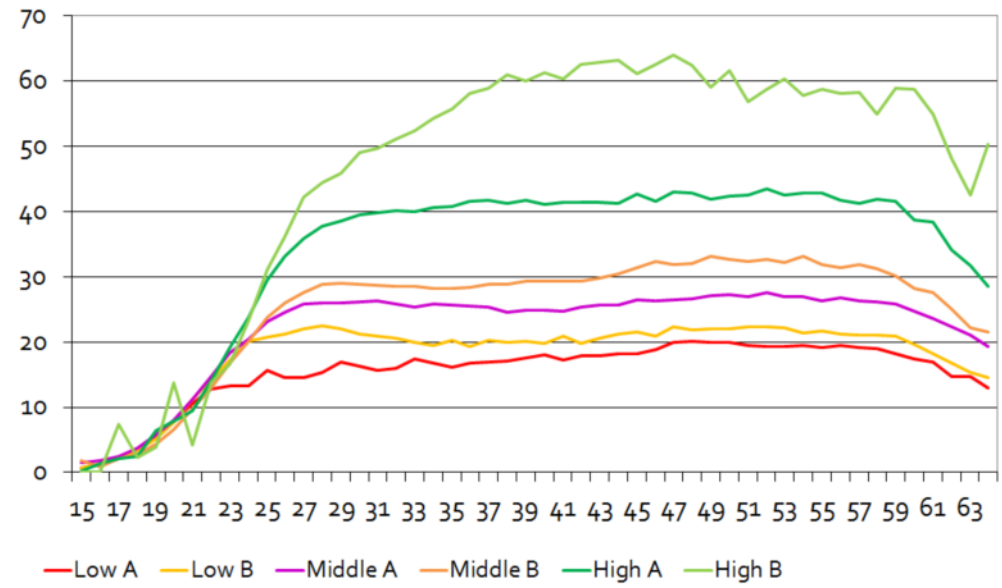


Figure 2.5 Age-lifetime income profile males by education level, 2009

euro (× 1000)

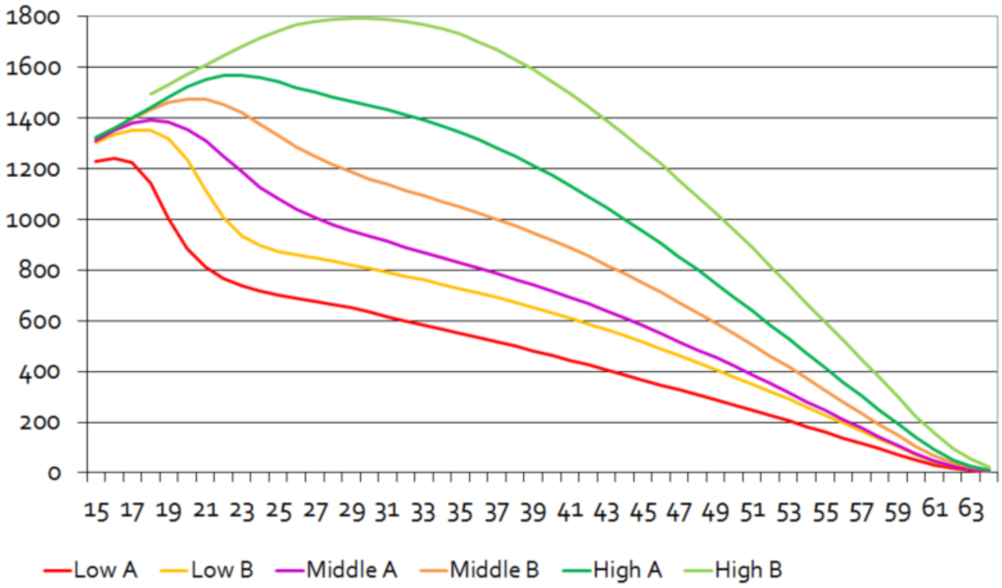
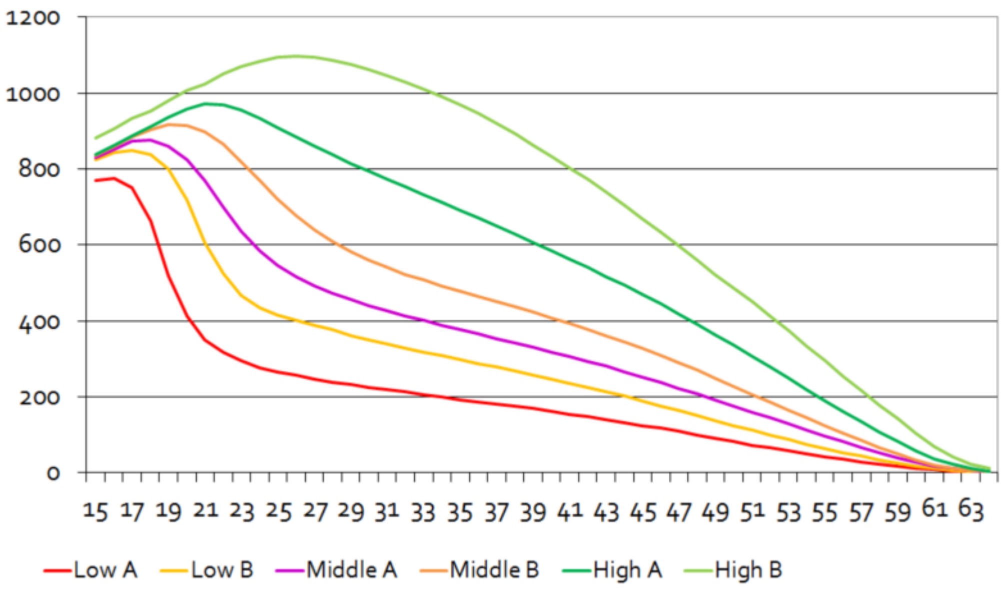


Figure 2.6 Age-lifetime income profile females by education level, 2009

euro (× 1000)



3. Results

This Section presents estimates based on Equation (2.3). These are estimates on the human capital stock in the Netherlands in the period 1999-2009 (Section 3.1). We also discuss investments in human capital (Section 3.2), of which the estimates are based on the method described in Section 2.2.2. We compare human capital and its formation to other types of capital, gross domestic product, and to other countries' human capital. We also look into the distribution of human capital and its growth by population characteristics.

3.1 The human capital stock

3.1.1 Nominal value

In 2009 the estimated nominal value of the human capital stock in the Netherlands was 6.7 trillion euro. This is an increase of 70% since 1999. We cannot assess whether this size of the stock is at a theoretically optimal size for the Dutch economy. But we may put the estimate into perspective with other types of capital and with gross domestic product in the Netherlands. Further we may compare the Netherlands to other countries.[20]

First we define national wealth as the sum of physical, natural and human capital (see Box 3.1). Figure 3.1 plots the shares of the various types of capital in (nominal) national wealth. Human capital appears to be much larger than the other components of national wealth. In 2009, national wealth amounted to 10 trillion euro, and the share of human capital in national wealth was about 67%. This share had not changed significantly since 1999.[21] [22] The share of physical capital was around 20% in the period under consideration. The ratio of nominal human capital to physical capital increased slightly from 3.2 in 1999 to 3.4 in 2009.

In international perspective, such a sizeable human capital stock is not uncommon. A recent empirical research study of the OECD estimated human capital for the statistical year 2006 for 15 countries, among which the Netherlands (Liu, 2011). The international average of the ratio human capital – physical capital was 4.7, and the estimate for the Netherlands was 3.6. Our own estimates give a ratio of 3.2 (for 2006).[23] The difference between these two estimates for the Netherlands is probably the result of differences in data and model assumptions for human capital. In any case, the Netherlands seem to rank relatively low with respect to the relative size of its human capital stock.

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[20] In Section 4 we also compare to estimates based on alternative methods.

[21] Including financial capital, national wealth would amount to 10.5 trillion euro in 2009. As the share of financial capital increases between 1999 and 2009, the share of human capital would have decreased slightly from 68% to 65%.

[22] If we had excluded dwellings (physical capital) and ground under these buildings (natural capital), national wealth would have amounted to 8.2 trillion euro in 2009, and the share of human capital would have been much higher (82%).

[23] Here we applied the National Accounts definition for 'physical capital' (fixed assets and inventories), similar to the OECD study. Excluding software, other intangible assets and cultivated assets gives a ratio of 3.3.

Box 3.1 The components of national wealth

National wealth is the sum of financial capital, physical capital, natural capital, human capital and other knowledge capital, and social capital. In the main text, we compare human capital with physical and natural capital. Where applicable we also note on financial capital and 'other knowledge capital'. There is no monetary measure for social capital. Below we give the theoretical definitions of the various types of capital, describe the statistics on capital stocks from the Dutch National Accounts [a)] and gross fixed capital formation (investments) from the Dutch Growth Accounts [b)], and denote where we deviate from these figures.

Physical capital We define physical capital as residential and non-residential structures, machinery and equipment and inventories as calculated by the National Accounts. We exclude software and 'other intangible assets', which we classify as part of 'other knowledge capital' (see below). We also exclude cultivated assets, being classified as natural capital (see below). Further, we do not consider consumer durables as productive capital so these assets are not taken into account. One might also argue that dwellings (and ground under these buildings, see 'natural capital') do not belong to the productive assets and should be excluded, though we did not so for the time being.

Natural capital Natural wealth is the sum of ground (for dwellings, buildings and agriculture), natural resources (or mineral reserves), and cultivated assets (e.g. livestocks and trees). We further define gross investments in natural capital as investments in cultivated assets, transfer costs of ground, and exploration of mineral reserves.

Human capital Defined as the sum of the lifetime incomes of all individuals in the population. [c)]

Other knowledge capital We define 'other knowledge capital' as the sum of computerised information, innovative property, and economic competencies. Computerised information is software. We define innovative property as the sum of R&D capital and 'other innovative property' such as copyright and license costs and new architectural and engineering designs. Economic competencies consist of brand equity (advertising and market research) and organisational structure (economic advice and management). Statistics Netherlands (GA 2010) included mineral exploration as innovative property and firm-specific human capital (on-the-job training expenditures) as an economic competency. We however classify mineral exploration as investment in natural capital (see above). We leave out firm-specific human capital to avoid double counting in the comparison with the lifetime incomes, leaving this issue for future research.[24] We do not have figures on capital stocks for intellectual property, except for software and 'other intangible capital'.[25] Statistics Netherlands (GA 2010) presents experimental figures on investment in intellectual property.

Financial capital Financial capital is the financial position of the Netherlands compared to the rest of the world. Figures on investments in financial capital are not available.

a) Statistics Netherlands, National Accounts 2010, Table EX 1.1, Non-financial and financial balance sheets of total economy. Also available from Statline, Macroeconomics , Income and wealth accounts, Non-financial and Financial balance sheets (in Dutch).
b) Experimental results from Statistics Netherlands (2012), The Dutch Growth Accounts 2010, Table 3.2, p.17. Part of these figures are official statistics available from Statline, Macroeconomics, Growth Accounts, Capital stocks (in Dutch).
c) Hence we add an estimate based on an income method to capital statistics based on (mainly) cost methods as standard in the National Accounts. In Section 4.5 we discuss income and cost methods.

[24] According to the Growth Accounts 2010, firm-specific human capital investments amounted to 5.4 billion euro in 1999 and 6.7 billion euro in 2009.
[25] R&D capital will be measured in the National Accounts in the near future.

Figure 3.1 Distribution of national wealth, 1999-2009

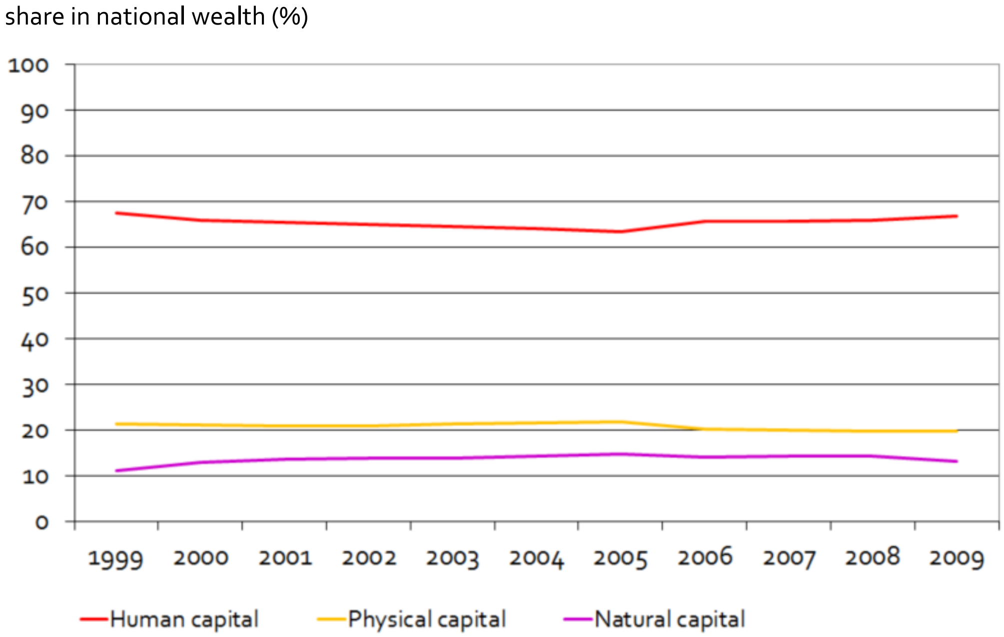
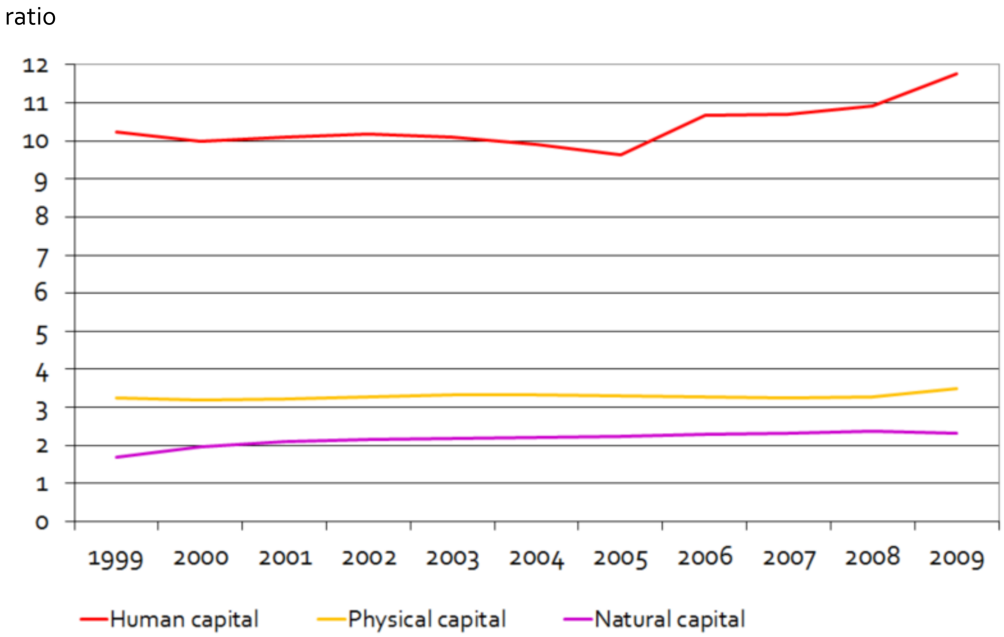


Figure 3.2 Ratio of capital to gross domestic product, 1999-2009



The production capacity of an economy is determined by the volume and quality of production factors such as capital. We may consider human capital also as a production factor. The human capital –output ratio indicates how many units of human capital are needed to produce one unit of output (or gross domestic product, GDP). The reverse of this ratio is the human capital productivity. Fraumeni (2012) advocates an extension of productivity analysis to human capital productivity. Up to now, productivity analyses focus on labour productivity (the ratio of output to labour) or multifactor productivity (MFP). Changes in human capital productivity have no 1-to-1 relationship with changes in labour productivity. This is particularly the case if human capital is measured as a present value of future potential, such as the lifetime income method does. If so, then the output variable actually should be measured also as a present value (of future output). But such a measurement is not applied yet for GDP, so we apply current GDP.

Figure 3.2 presents the ratios of human capital and physical capital to (current) GDP. The value of human capital appears to be about 10 times larger than that of GDP in 1999, and in 2009 this ratio has increased to nearly 12. The ratio is much higher than the physical capital – GDP ratio, which is around 3.3 in the period under consideration. The OECD study (Liu, 2011) estimated an international average ratio of human capital – GDP of 10.6 for the 15 countries in 2006. The ratio for the Netherlands was estimated the lowest of all countries, namely 8.3. Our estimate results in a ratio of 10.7. In Section 4.2 we elaborate on international differences in estimates of the human capital – GDP ratio.

Figure 3.2 further shows that the ratio of human capital to GDP fluctuates a little over time, whereas that of physical capital – GDP is stable. This is probably due to the fact that earnings, an input variable for the estimates, fluctuate over time because of short term cyclical changes. The human capital – GDP ratio slightly declines from 2002 to 2005. In this period the level of human capital remained relatively stable while GDP rose steadily. After 2005 human capital increased faster than GDP.[26]

The national human capital stock was calculated by adding up the lifetime incomes of all individuals in the working-age population (see Equation 2.4). Table 3.1 shows the average nominal lifetime labour incomes and their annual average growth rates in various subgroups in the population by sex, age and education level. Table 3.2 presents the shares of the subgroups in total human capital.

The average lifetime income rose from 367 thousand euros in 1999 to 606 thousand in 2009, an increase of about 65%. The total human capital stock rose with 70%, implying that the number of individuals with higher incomes had increased. The human capital embodied in females was lower than that of males in the whole period under consideration. This is due to the lower annual earnings of females, who relatively often work part time.[27] But the difference decreased over time as females were catching up. Their average lifetime income was around 40% of that of males in 1999, and more than 50% in 2009. Their share in the human capital stock rose from 26.9% in 1999 to 33.5% in 2009.

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[26] A part of the fluctuation around 2005 and 2006 might stem from the data. In a revision in 2012, the assignment of education levels to some individuals in the SSD has been adjusted downwards for 2006 and beyond, but not yet for the earlier years up till 2005. Therefore we made a rough correction for the number of individuals at some education levels, which smoothed the change around 2005/2006 a little. But even if we worked with officially revised data for 2005 and earlier, the overall development of human capital per capita would not change much.

[27] One might consider to adjust for this difference in working hours. Then one may estimate a 'full time equivalent' of earnings of part time workers. This implies the estimation of a human capital potential which is not utilized (yet). Section 4.4 discusses such an adjustment.

Table 3.1 Lifetime labour income per capita, 1999-2009

	Average nominal lifetime labour income per capita (× 1000 Euro)			Average annual growth (%)
	1999	2004	2009	1999-2009
All individuals	367	442	606	5.02
Sex				
… Male	528	611	800	4.14
… Female	201	270	409	7.14
Age				
… 15-24	576	640	1037	5.88
… 25-34	526	684	895	5.32
… 35-44	393	514	683	5.52
… 45-54	218	285	392	5.88
… 55-64	44	63	92	7.43
Education				
… Low A	173	193	401	8.40
… Low B	292	316	495	5.26
… Middle A	339	400	524	4.37
… Middle B	471	551	653	3.26
… High A	484	591	748	4.37
… High B	714	840	1009	3.47

The average lifetime income of younger people was higher than that of older people. This is because of the longer expected working life for younger people, and because they have more often reached a higher education level. The ratio of lifetime incomes of older individuals (aged 55 to 64) to that of younger people (aged 15 to 24) in 2009 was somewhat higher than in 1999. The ratio peaked around 2004, due to a temporary decrease in lifetime incomes for the younger people. The share of the youngsters in the human capital stock rose from 27.3% to 31.2% in 2009. However, we see that the number of older people increased, and consequently their share in the human capital. The ageing of the population should be offset by education, in order to avoid a decrease in total human capital in the longer run.

The lifetime incomes were higher for those with higher education than those with lower education, because of higher earnings. The ratio of the lifetime income of those with a High B education level to that of those with Middle B did not change much. The ratio of High B to Low A shows more fluctuations, mainly because of the volatility in lifetime incomes of individuals with Low A education levels. Those with Middle A and B contributed most to the human capital stock (more than 40%). But the share of the higher educated (High A and B) in the total human capital stock increased from 28.4% in 1999 to 33.0% in 2009. Education is an important driving factor in human capital formation.

Table 3.2 Distribution of human capital by population characteristics, 1999-2009

		1999	2004	2009
Total human capital	*bln euro*	3949	4869	6743
Sex				
... Male	%	73.1	69.8	66.5
... Female		26.9	30.2	33.5
Age				
... 15-24	%	27.3	25.5	31.2
... 25-34		33.2	30.8	26.5
... 35-44		25.2	27.7	25.1
... 45-54		12.6	13.6	14.3
... 55-64		1.8	2.5	2.9
Education				
... Low A	%	7.2	6.1	8.8
... Low B		20.0	16.1	16.4
... Middle A		21.3	19.6	17.6
... Middle B		23.0	25.8	24.1
... High A		16.3	18.9	18.8
... High B		12.1	13.7	14.2

For that matter, the difference in lifetime incomes per capita between education levels apparently accords with international estimates of the return to (higher) education, which varies around 8% per additional year of schooling. For instance, the percentage difference between High A and High B in 2009 is around 35%, which represents an increase of about 11.6% per year as an individual with High A is assumed to spend three years to obtain High B. The return to schooling from Middle B to High B (with five years of schooling) is 11.0% per year in 2009.

3.1.2 Volume change

A substantial part of the development of the value of human capital is determined by the 'price' of human capital. This price is linked to short run changes in the labour market (e.g., wage increases). The fundamental long run changes in embodied knowledge (e.g., an increase in the education level) are expressed by the real or volume developments in the human capital stock. Table 3.3 presents the wealth account for the Netherlands, with value, quantity and prices of the different types of capital in selected years between 1999 and 2009. The wealth account shows that the volume growth of human capital (0.27%)[28] was much lower than that of physical capital (1.69%) and natural capital (0.51%). The low real growth rate of human capital rise questions on the underlying causes.

[28] We applied the Laspeyres index to construct volume indices for human capital (see Appendix D).

Table 3.3 Value, volume and prices of national wealth components, 1999-2009

		Level of wealth component			Average annual growth (%)
		1999	2004	2009	1999-2009
Value	*billion Euro*				
National wealth		5853	7594	10068	
Physical capital		1252	1638	2001	
Natural capital		653	1087	1324	
Human capital		3949	4869	6743	
Volume index	*1999=100*				
National wealth		100.0	103.7	106.3	0.61
Physical capital		100.0	109.0	118.4	1.69
Natural capital		100.0	102.5	105.2	0.51
Human capital		100.0	102.3	102.7	0.27
Price index	*1999=100*				
National wealth		100.0	125.1	161.8	4.81
Physical capital		100.0	120.1	135.1	3.00
Natural capital		100.0	162.4	192.6	6.55
Human capital		100.0	120.6	166.3	5.09

Volume changes in human capital consist of two components: the growth of the population and real changes in human capital per capita. Most of the volume growth of human capital arose from the growth of the working-age population. In the period 1999-2009, this population increased with 0.33% per year (see Figure 3.3 and Table 3.4). In contrast, the volume growth of human capital per capita was negative (-0.06% per year). This estimate apparently indicates that the Netherlands do not fulfil the condition of a sustainable growth path (non-decreasing human capital per capita, see Section 2.1).

OECD (Liu, 2011) estimated for 12 countries time series on human capital (varying between 1997 and 2007). Because of lack of OECD data, the Netherlands were not in this group of 12. Compared to the volume growth of human capital in those 12 countries, which varied between 0.5% to 1.3% per year, the growth in the Netherlands (0.27%) is relatively low. This is due to the combination of the relatively low population growth and the decreasing human capital per capita. In 4 of the 12 countries in the OECD analysis, there was also a decrease of human capital per capita, with 0.2% to 0.3% per year.[29] But those 4 countries experienced a higher population growth than the Netherlands.

[29] Those 4 countries are Israel, Korea, Norway and the US. In 4 other countries (Australia, Canada, France and New-Zealand), there was zero growth of human capital per capita. In 3 countries (Italia, Spain and the UK) it increased with 0.1% to 0.3% per year. Poland is an outlier with 0.9%.

Figure 3.3 Volume of human capital, human capital per capita, and population, 1999-2009

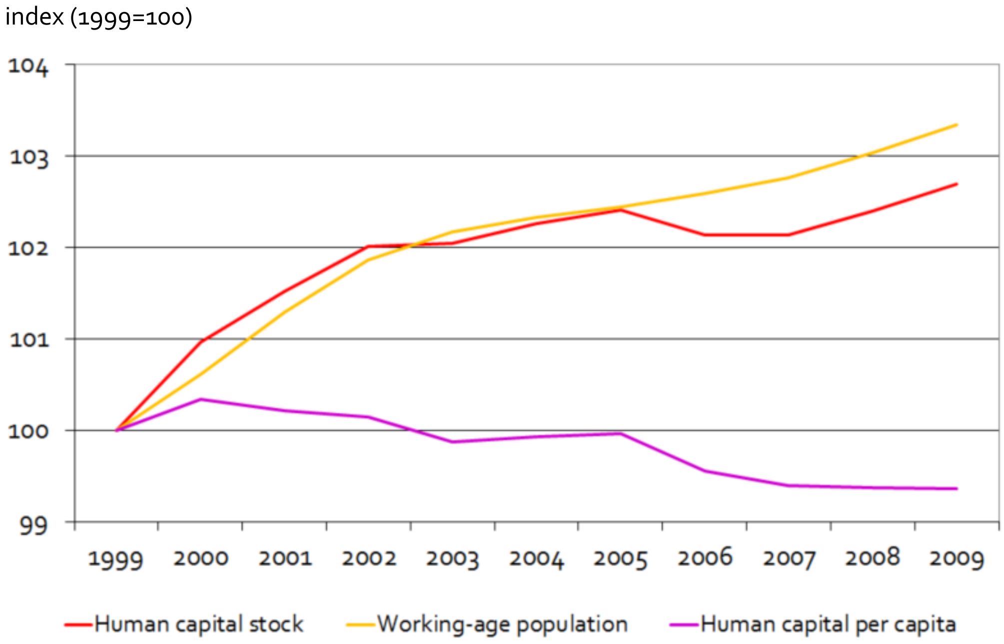


Table 3.4 Components of human capital volume growth (average annual growth, %), 1999-2009

Human capital stock	0.27
of which	
... Working-age population	0.33
... Human capital per capita	-0.06

Table 3.5 First order effects on growth of human capital per capita (average annual growth, %), 1999-2009

Human capital per capita	-0.06
first order effect (of shifts in composition by)	
... Sex	-0.03
... Education	0.66
... Age	-0.65

Note: the sum of the contribution of the shifts by characteristics differs from the overall change in human capital per capita, as the respective contributions are first-order approximations to the index of human capital per capita.

We observe shifts in the composition of the working-age population that resulted in the negative development of human capital per capita in the Netherlands (Table 3.5). The increase in the average education level in the population could not offset the ageing of the population. The average age of the population rose from 38.8 in 1999 to 40.2 years in 2009 (see also Table 2.2). This structural shift had a negative impact on the growth of human capital per capita of 0.65% per year. Older individuals have higher annual earnings but have a shorter remaining working life span to their retirement, and consequently less human capital than younger individuals.

The increase in education level between 1999 and 2009 had a positive effect of 0.66% per year. The share of individuals with higher education (High A and B) in the population rose from 18.6% in 1999 to 23.8% in 2009, as was mentioned before (Table 2.2). Education increases expected future annual earnings and consequently human capital. However, the increase in education could not offset the negative ageing effect. The negative impact of the structural shift between males and females (-0.03%) is very small. The increased labour participation of females and the increase of their human capital was too small to play a significant role in the change of human capital per capita.

Table 3.6 presents the growth contributions of the various subgroups in the working-age population to total human capital growth, total population growth and total growth of human capital per capita. Concerning the differences between the sexes, most growth of human capital stem from human capital growth in the female subpopulation. This is mainly because the number of females in the working-age population had increased, and to a lesser extent the increase in human capital per female. More interestingly, we observe that the female contribution to the growth of human capital per capita was positive while that of males was negative in the period under consideration. We know that the volume growth of human capital per capita within the male subpopulation was negative. Apparently the investments in education by males was dominated by the effects of the ageing of the male subpopulation.

The contribution of the individuals aged 25-34 to human capital volume growth diminished, mainly because the number of individuals in this subgroup decreased. The middle group aged 35-54 contributed most to overall growth. There was a high positive growth contribution of human capital per capita in the age group 35-44, and a growth in the number of individuals of age 45-54. The ageing of the population is represented by the growth of the oldest subgroup of age 55-64. Because the growth contribution to human capital per capita by this subgroup had strongly decreased, the contribution to human capital growth was nevertheless small, despite the growth in the number of individuals. The volume of human capital per capita in this subgroup had increased, but apparently not enough to contribute positively to the overall growth of human capital per capita.

Individuals with education level Low B (such as secondary vocational education, vmbo) and Middle A (such as secondary general education, havo) contributed increasingly less to the volume growth of human capital, mainly because of the decrease of the number of individuals in those subgroups. The three highest education levels (such as vwo and mbo-4, and higher education), each contributed equally (around 0.30%-points) to the overall growth of human capital. But only High B (higher general education, wo; masters of higher vocational education hbo) contributed positively to human capital per capita. This while the volume of human capital per capita within the population with High A had actually decreased. Apparently there are not sufficient investments in education as a compensation for the ageing in the subgroup. If this decrease continues in the future, the growth contribution of individuals with High B to human capital per capita will finally become also negative.

According to the OECD (Liu, 2011), some economies do not invest sufficiently in education to offset the negative effect of the ageing of the population. Because the population growth in the Netherlands is relatively low in international perspective and may not become higher, a higher growth of human capital should arise from growth in human capital per capita.

Table 3.6 Growth contribution by population characteristic (%-points), 1999-2009

	Human capital	Population	Human capital per capita
Total volume growth	0.27	0.33	-0,06
Sex			
… Male	0.01	0.13	-0,12
… Female	0.25	0.20	0,05
Age			
… 15-24	0.19	0.14	0,05
… 25-34	-0.41	-0.46	0,05
… 35-44	0.17	-0.04	0,22
… 45-54	0.22	0.17	0,06
… 55-64	0.07	0.51	-0,44
Education			
… Low A	0.01	-0.15	0,15
… Low B	-0.43	-0.44	0,01
… Middle A	-0.30	-0.20	-0,10
… Middle B	0.33	0.50	-0,17
… High A	0.30	0.33	-0,04
… High B	0.30	0.25	0,06

Note: the sum of the contribution of the characteristics does not exactly match with overall volume growth.

3.2 Investment in human capital

3.2.1 Nominal value

Section 2.2 described the mathematical decomposition of the change of the human capital stock into gross investment, depreciation and revaluation. Box 3.1 defined the gross fixed capital formation of various types of capital in the national economy. Gross investment in human capital (investments in education and immigration, and the entering of 15-year olds into the working-age population) appears to be much larger than investment in physical and natural capital. From Figure 3.4, which shows the distribution of total national gross investment, we observe that the share of investment in human capital is above 70% in the whole period under consideration. The ratio of human capital investment to physical capital investment increased from 2.5 in 1999 to 3.0 in 2009.

Figure 3.4 Distribution of national investment, 2000-2009

share in national investment (%)

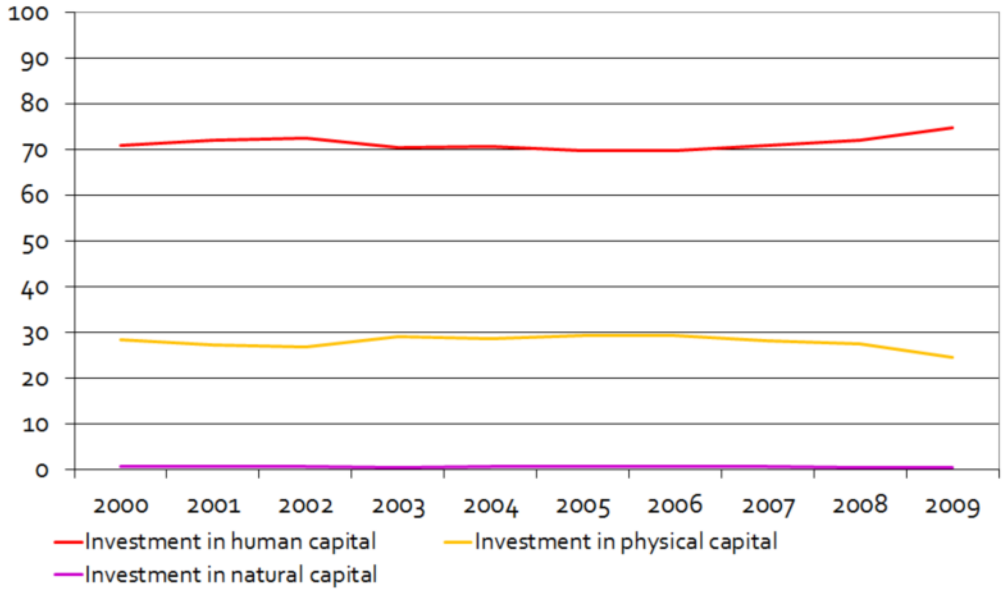
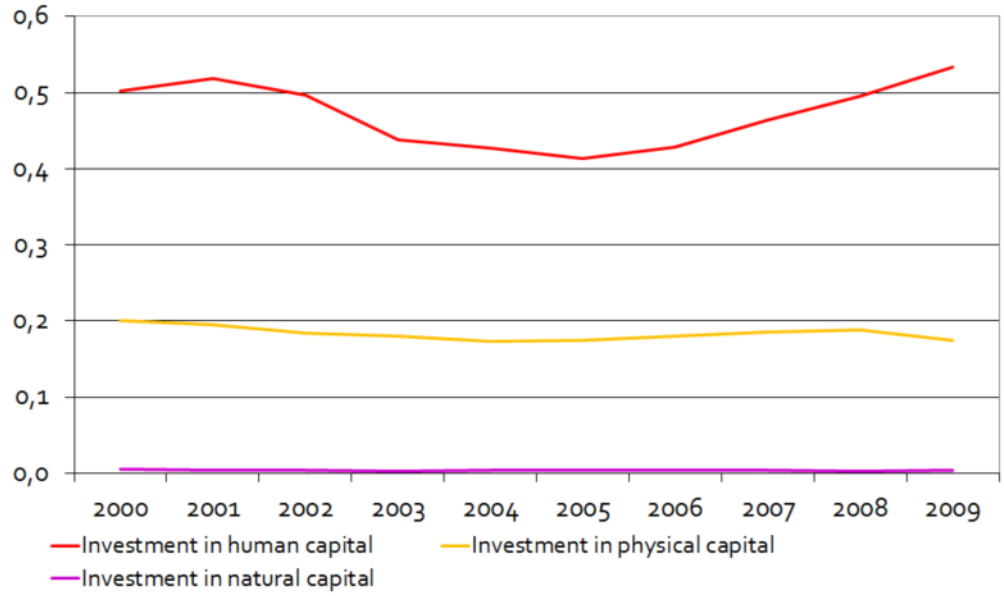


Figure 3.5 Ratio of investment to gross domestic product, 2000-2009

ratio



Compared to GDP, gross investment in human capital is also sizeable, on average half of GDP. Figure 3.5 shows that the ratio of investment in human capital to GDP slightly decreased up to 2005, only to increase again after then. The decrease was caused by a temporary levelling off of the value increase of human capital investment while GDP continues to increase steadily. For that matter, GDP consists of expenditure categories: consumption, investments, exports and imports. The category 'investment' is composed of investments as defined by the National Accounts, hence excluding human capital investments. If we would include the latter into the official GDP, this GDP would increase significantly, and the share of human capital investment would be about one third.

Turning to the other components of changes in human capital (depreciation and revaluation), we observe large fluctuations of the overall change in human capital over time. This is due to large changes in the revaluation component. There seems to be some cyclicality in revaluation related to economic fluctuations and the state of the labour market. Revaluation was relatively small in the period 2002-2005, and in 2009. This was probably because of slower growth or even decrease in labour participation rates and in worker earnings in these years. In 2006 there was a large upwards peak. The lifetime time incomes of particularly young individuals (up to age 35) made a jump around that time. In the end, net investment (gross investment net of depreciation) made a smaller contribution to the change in human capital than revaluation did, and the contribution was even negative. The average growth between 2000 and 2009 for nominal gross investment (4.23%) was lower than for depreciation (4.68%) and revaluation (6.61%). Because of the large nominal changes in revaluation which blurs real developments, we turn to a volume growth analysis.

3.2.2 Volume change

Figure 3.6 gives the volume developments in human capital with base year 2000=100. What catches the eye is that depreciation and revaluation of human capital develop gradually, while the volume of gross investment in human capital fluctuates. Policy changes and changes in economy and labour market more quickly affect investments in education and immigration. This is not the case for revaluation and depreciation, because changes in these volume components are related to long run changes in the composition of the population.

On average, gross investment rose annually with 0.28% per year (see Table 3.7). The volume of investments was lower between 2003 and 2007 than in 1999. This is due to a decrease in investments in education and immigration (see Figure 3.7). From 2007 onwards these investments improve again. In contrast, the number of individuals aged 15 that enters the working-age population from 2000 onwards was repeatedly higher than in 1999.

Figure 3.6 Volume development of gross investment, depreciation and revaluation of human capital, 2000-2009

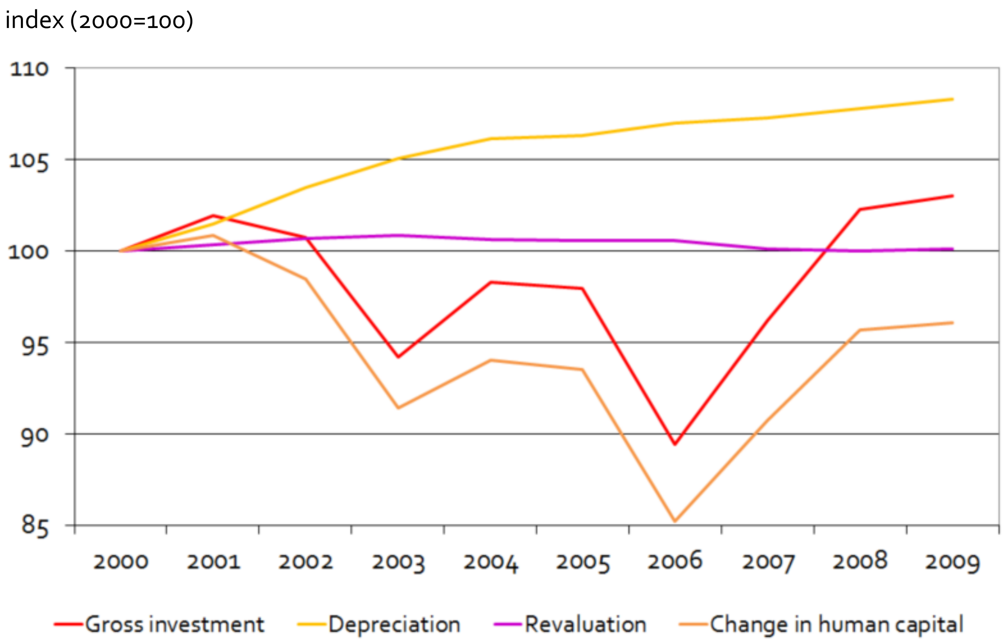


Table 3.7 Decomposition of volume change of human capital, 2000-2009

Gross investment in human capital	0.28
... Investments in education and immigration	0.36
... New workers (entry of 15-year olds)	0.20
Depreciation of human capital	0.94
... Ageing of population	1.03
... Decrease in number of workers (by death, emigration, retirement)	-2.44
Net investment in human capital	-8.05
Revaluation	0.00
Total volume change in human capital stock	-0.55

Meanwhile depreciation rose steadily with 0.94% per year. The growth rates of the two components of depreciation had opposite signs, however (see Figure 3.8). There were less and less individuals who retired early, died before age 65, or emigrated. Hence depreciation due to quitting of individuals out of the working-age population decreased with 2.44% per year (see Table 3.7). Net investment in human capital nevertheless decreased because of the increase of depreciation due to ageing (with 1.03% per year). As the volume of depreciation due to ageing is significantly larger than that of quitting, the impact of ageing dominates. In order to compensate the effect of ageing, the increase in gross investment in education from 2007 onwards should continue in the near future.

The volume development of revaluation, finally, is as expected: there is hardly any change to observe in Figure 3.6. The volume component of revaluation measures the increase in the number of individuals in the working-age population given their personal characteristics (sex, age and education level). The nominal value of revaluation mainly consists of a price-component. This price component consists of sizeable short run fluctuations in the value of human capital. Fundamental changes in embodied knowledge and competencies of individuals are mainly expressed in the volume development of gross investment in human capital.

Figure 3.7 Volume development of gross investment and its components, 2000-2009

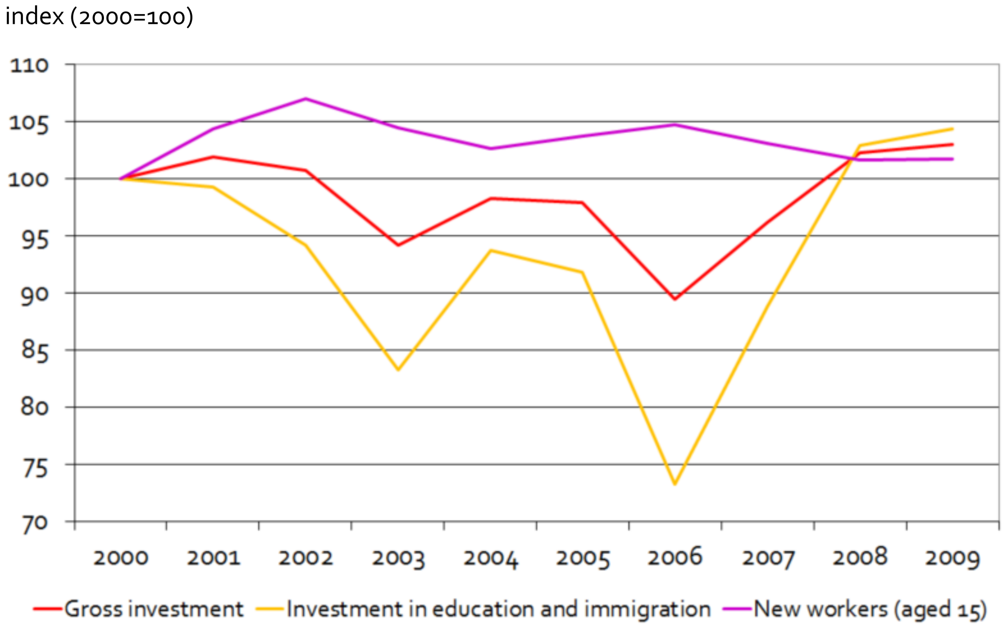
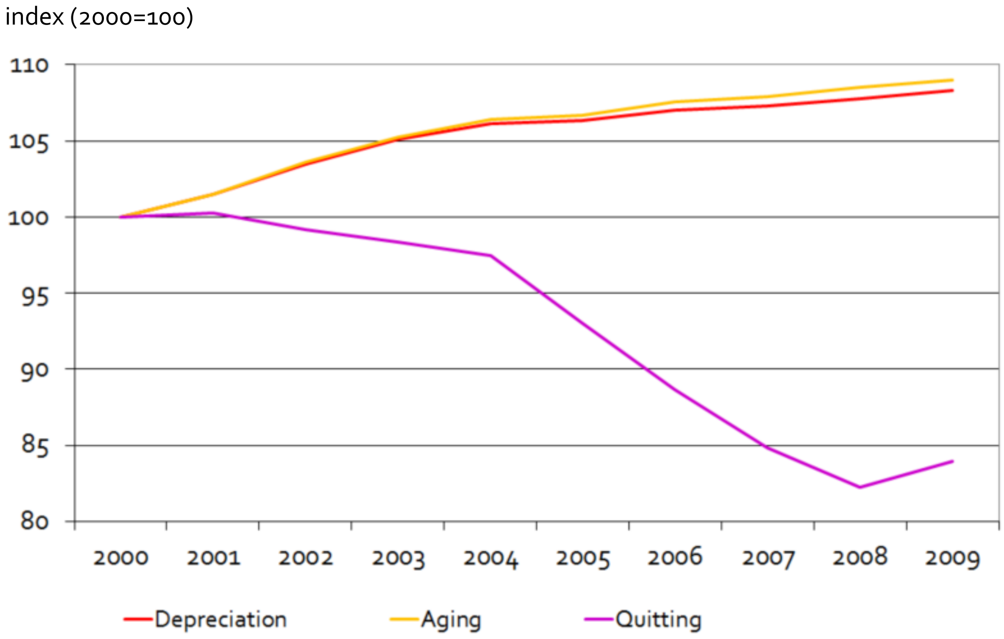


Figure 3.8 Volume development of depreciation and its components, 2000-2009



4. Discussion

Are the humans capital estimates as described in Section 3 plausible? The comparison of the estimates to other types of capital, GDP and to estimates for other countries give some feeling for the plausibility of the estimates. The estimates for the Netherlands are in line with those for other countries. But human capital is relatively large compared to other types of capital and to GDP. This raises questions on the methodology and data. For instance, changes in the assumptions on the real income growth rate and the discount rate affect the estimates (Section 4.1). Further, we may compare the model applied to alternatives. Here we apply two alternative models: a simple benchmark model based on the labour compensation share in GDP (Section 4.2) and an alternative algorithm that distinguishes between workers and students (Section 4.3). Another discussion focuses on underutilization of human capital due to part-time work (Section 4.4). A final but important issue is the linking with the official National Accounts. What would a satellite account human capital look like (Section 4.5)? Appendix E lists more other future research issues on methodology and data.

4.1 Sensitivity analysis on growth and discount rates

Up to now we applied a real income growth rate *g* of 1.63% and a discount rate *r* of 4.58%. To what extent would the human capital estimates change with alternative values? Table 4.1 presents estimates for the level of the human capital stock and its volume growth with values for *g* and *r* which are 1%-point lower or higher than the chosen values.

Table 4.1 Alternative real income growth and discount rates

	Income growth rate *g*	Discount rate *r*	Level 2009	Relative to baseline	Volume growth 1999-2009	Difference with baseline
	%	*%*	*bln euro*	*%*	*%*	*%-point*
Baseline estimate	1.63	4.58	6743		0.27	
Change in g						
Minus 1%-point	0.63	4.58	5925	87.9	0.28	0.01
Plus 1%-point	2.63	4.58	7735	114.7	0.25	-0.02
Change in r						
Minus 1%-point	1.63	3.58	7719	114.5	0.25	-0.02
Plus 1%-point	1.63	5.58	5956	88.3	0.28	0.01

With respect to the impact on the level of the stock, the factor *(1+g)/(1+r)* in Equation (2.1) shows that the effect of an increase (decrease) in the real income growth rate *g* is similar to the effect of a decrease (increase) in the discount rate *r*. Rising the income growth rate with 1%-point or decreasing the discount rate with 1%-point leads to a value for the human capital stock which is nearly 15% higher than our baseline estimate. Decreasing the income growth rate with

1%-point or rising the discount rate with 1%-point gives a new estimate which is about 12% lower. In contrast, the growth rate of the volume stock does not change much with alternative values for the real income growth and the discount rate. The differences (measured in %-points) between the volume growth rate in the baseline estimate and the new growth rate estimates are near zero in all cases.

In sum, a change in the rates has a significant effect on the level of human capital stock (in current prices), but only a very small effect on the volume growth of the human capital stock. This conclusion also apply for other years than 2009 and for investment estimates. Other researchers also found similar results, e.g., Gu and Wong (2010), Christian (2011) and Wei (2009).

4.2 Benchmark estimates of human capital-GDP ratio

In order to get some feeling for the plausibility of the level of the human capital stock compared to that of GDP, we apply a benchmark method. This alternative estimate is calculated with help of the share of workers' compensation in GDP. We suppose that individuals in the working-age population are expected to work for *n* years on average from some year *t* up till their retirement at age 65. For instance, in 2009, the average age in the working-age population was 40,2 years. This gives n = 24,8 (= 65 – 40,2). We denote *w* being the share of workers' compensation in GDP. Then we calculate the human capital-GDP ratio *H/Y* in year *t* as follows:

$$(4.1) \quad \frac{H}{Y} = w \times \sum_{i=0}^{n-1} \left(\frac{1+g}{1+r} \right)^{i}$$

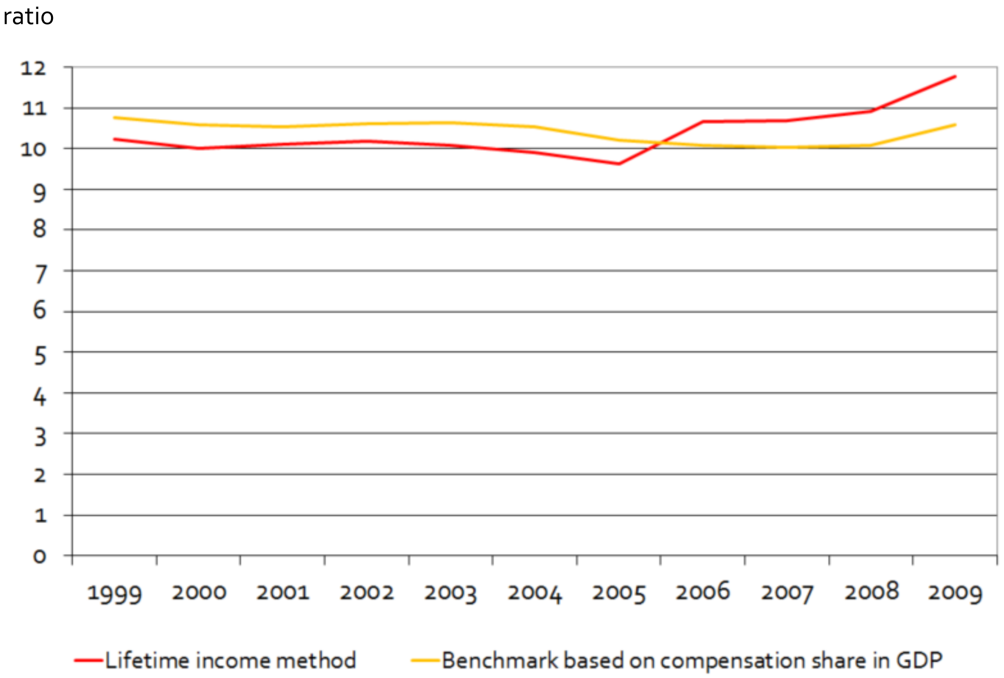
We applied aggregate data from the official Labour Accounts on labour compensation of employees, and complemented this with unpublished data on labour compensation of the self-employed. Figure 4.1 compares the results of the benchmark model with those of the lifetime income method. We see that the results of both approaches do not deviate much from each other.[30] Causes of the differences may be, among other things, in the simple assumption in Equation (4.1) on the number of remaining working years (*n*). In any case, both methods result in a human capital stock in the same order of magnitude (around 10 times GDP). Hence the lifetime income method seems to give plausible results, compared to the benchmark model.

As was mentioned in Section 3, the OECD estimated national human capital stocks for 15 countries, among which the Netherlands (Liu, 2011). These estimates were based on OECD data. The study reported an average ratio of human capital stock to GDP of 10.6 for the 15 countries around 2006. The ratio for the Netherlands was estimated at 8.3, the lowest of all countries. Our own estimate based on SSD data resulted in a much higher human capital-GDP ratio of 10.7 in 2006. The difference between the estimates is explained by differences in assumptions and data. We applied a growth rate of 1.63%, while Liu (2011) used a growth rate of 1.23% for the Netherlands (based on the real growth of wages per employee in the period 1960-2007). Applying the OECD growth rate we would estimate a ratio of 10.1, which is still significantly higher than the OECD estimate of 8.3. A more important cause of the difference is the data on labour income. We defined labour income as labour compensation of employees and self-employed, whereas the OECD applied data which were benchmarked to wages and

[30] See footnote 26 on the fluctuation around 2005/2006.

salaries of employees in the National Accounts. If we applied data on wages instead of labour compensation, we would have estimated a human capital – GDP ratio of 8.3 with g = 1.63%, or 7.9 with g = 1.23%.[31] Remaining differences might be, among other things, in definitions of variables (SSD versus OECD data) and differences in assumptions such as education levels and study durations.

Figure 4.1 Human capital to GDP ratio, 1999-2009



We also benchmarked the OECD estimates for the various countries in 2006 to the model in Equation (4.1). We applied OECD national accounts data on the share of employees' wage and salaries in GDP. We applied the ratio of total employment to the number of employees to raise the employees' share to an estimated wage share of employees and self-employed. Further we applied the OECD assumptions on the discount rate r and the national growth rates g.[32] Data for n, the average of remaining years to work, were derived from the countries' median age of the total population in 2005, plus one additional year. The data for median age in 2005 were from the UN World Population Prospects, revision 2012. For instance, the median age for the Dutch population in 2005 was 38.9. We proxied the average age in the Dutch working age population in 2006 by 39.9 (= 38.9= 1), and calculated n as 65 – 39.9 = 25.1.[33]

Figure 4.2 shows the results of the benchmark estimate according to Equation (4.1) and the abovementioned data sources for 14 countries.[34] The benchmark estimates are generally somewhat lower than the OECD estimates. The average ratio of human capital to GDP

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[31] We assigned the average wage of employees to the self-employed individuals. The OECD estimate implicitly includes the self-employed as all individuals in the population are taken into account in the estimation of the national human capital stock.

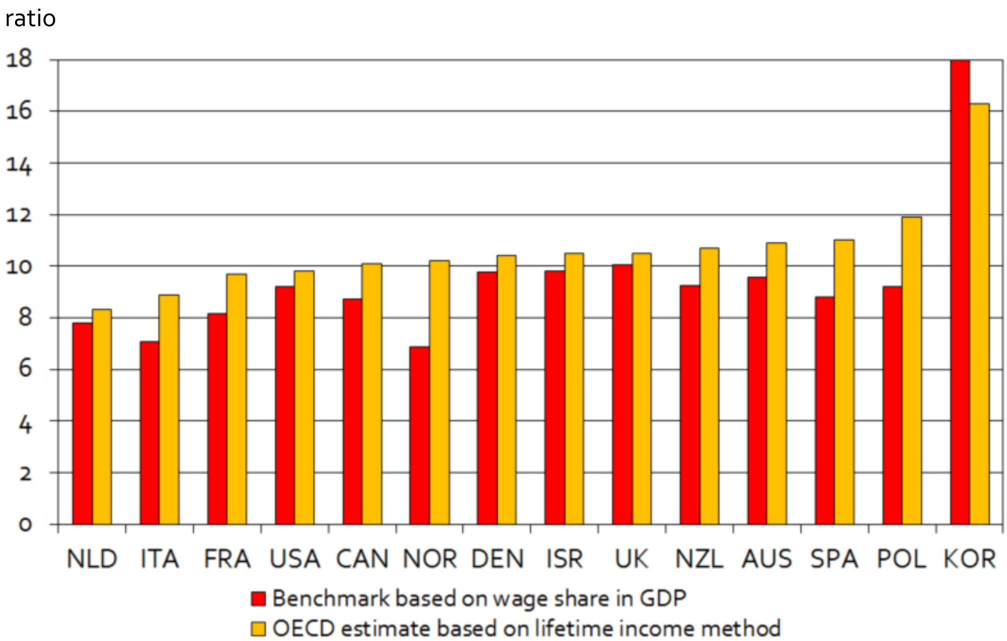
[32] The discount rate was fixed at 4.58% for each country in the OECD study, while the income growth rate differed across the 15 countries.

[33] The average age of the working age population according to our human capital database based on SSD data was 39.9 years in 2006.

[34] Excluding Romania.

according to the benchmark is 9.4, whereas the OECD average was 10.7 excluding Romania. The international ranking is also different. The Netherlands rank higher than Norway and Italy in the benchmark, but still lower (7.8) than average. Korea is estimated even higher in the benchmark than in the OECD study, whereas Poland, Spain and Norway are estimated much lower. But again both methods result in a human capital stock in the same order of magnitude, that is, a human capital stock valued at several times of the value of GDP.

Figure 4.2 Benchmarking the OECD application of the lifetime income method: Human capital to GDP ratio in 14 countries, 2006



International differences in the benchmark estimate are explained by differences in wage share *w*, the growth rate *g*, and the remaining years to work *n*. If we fix two of the three variables at the same level, then we would observe a difference in ranking caused by the third variable. Fixing the wage share at, say, 46.8% and the growth rate at 1.99% (the international averages), but keeping the international differences in *n*,[35] does not change the ranking of the Netherlands (3rd from below). Fixing the wage share at 46.8% and *n* at 27 but keeping the international differences in *g* ranks the Netherlands at 2nd from below. However, if we fix *g* at 1.99% and *n* at 27 but let the wage share vary across countries, this leads to a much better ranking of the Netherlands (ranking 9th). This small tentative analysis seems to indicate that the relatively low growth rate *g* and remaining years to work *n* are the restricting factors for the relative size of the human capital stock of the Netherlands.

But countries with high growth rates do not always have the highest human capital – GDP ratio. This is particularly the case for France and Italy, and to a lesser extent, Poland and Spain (referring at the benchmark estimates). Denmark and the UK (and to a lesser extent Australia) with an average growth rate have a relatively high human capital – GDP ratio due to their high relatively high wage share, notwithstanding a below-average *n*. Korea is an outlier with a high

[35] The wage share for the Netherlands is 44.7%, the growth rate is 1.23% and *n* is 25.1.

growth rate, *n*, and wage share. The Netherlands are ranking low because of a wage share just below the international average, and a relatively low growth rate and *n*. For that matter, the crude benchmark model has of course some flaws. It is not a realistic assumption that countries' growth rates remain to differ strongly in the future, particularly if the discount rate is fixed at the same level internationally. The wage share would increase in countries with a high growth rate compared to countries with a low growth rate.

Explanation of the international position of the Netherlands according to the OECD estimates is beyond the scope of this report. It may be partially in international differences in quality of the data, assumptions (on *g* and *r*) and in the methodology (e.g., measuring the effects of education but not those of other factors such as training on the job or health investments). The OECD study observed that Dutch females and Dutch young individuals (aged 15 to 34) contribute relatively little to the national human capital stock. The contribution of Dutch higher educated individuals (ISCED 5 and 6)[36] is just average. Korean females also contribute relatively little, but Korea has relatively more higher educated individuals and more young people. The OECD international comparison of the real human capital per capita and GDP per capita suggested that the Netherlands has a relatively low level of human capital per capita despite a relatively high GDP per capita.

4.3 The worker-student model as alternative algorithm

The model with two stages of life as described in Equations (2.2) and (2.3) is currently the common method in the international field. But alternative algorithms are conceivable. Liu and Greaker (2009) developed such an alternative model, which they applied on data for Norway. Their model requires data at micro-level, especially enrolment data for all ages (hence enrolment is not restricted to the younger population up to a fixed age between 34 and 40), and data on (part time) earnings of students. As we have such micro-data, we can apply this alternative model and compare the results with those of the common model in Section 2.2.

Liu and Greaker (2009) break down the population into 'workers' and 'students', depending on their primary activity. 'Workers' may pursue studies, while 'students' may have a part time job. Note that the label 'worker' in this model does not imply an individual has actually a job. Some 'workers' are unemployed, but willing to work. 'Students' belong to the labour force if they have a job or are willing to work. The model in Section 2.2 supposes that the part time earnings exactly offset the direct costs of a study (conform Mincer, 1974), whereas the 'worker-student' model explicitly accounts for earnings of students. But the worker-student model has one important restriction. It focuses on the labour force, raising the issue how to value the human capital of the non-labour force in the working-age population. In order to compare with the results based on the common method in Section 2.2, we need to deal with this valuing problem. Formally, the worker-student model has an algorithm for 'workers' and one for 'students' to calculate lifetime incomes:[37]

[36] ISCED = international classfication of education levels. ISCED 5 and 6 correspond with education levels High A and High B in the current report.

[37] Again we suppressed the subscript (*s*) for sex.

Working-and-possibly-studying

$$(4.2) \quad LIW_{e,a} = EMR^{LF}_{e,a}\ AIW_{e,a} + \left\{1-\sum_{\bar{e}} ENR^{LF}_{e\to\bar{e},a}\right\}\left(SUR_{a+1}\ EMR^{LF}_{e,a+1}\ LIW_{e,a+1}\ (1+g)/(1+r)\right) + \left\{\sum_{\bar{e}} ENR^{LF}_{e\to\bar{e},a}\right\}\left(\sum^{T} SUR_{a+t}\ EMR^{LF}_{e,a+t}\ AIS_{e\to\bar{e},a+t}\ \left[(1+g)/(1+r)\right]^{t} + SUR_{a+T+1}\ EMR^{LF}_{\bar{e},a+T+1}\ LIW_{\bar{e},a+T+1}\ \left[(1+g)/(1+r)\right]^{T+1}\right)$$

Studying-and-possibly-working part time

$$(4.3) \quad LIS_{e,a} = EMR^{LF}_{e,a}\ AIS_{e\to\bar{e},a} + \sum^{z} SUR_{a+t}\ EMR^{LF}_{e,a+t}\ AIS_{e\to\bar{e},a+t}\ \left[(1+g)/(1+r)\right]^{t} + SUR_{a+z+1}\ EMR^{LF}_{\bar{e},a+z+1}\ LIW_{\bar{e},a+z+1}\ \left[(1+g)/(1+r)\right]^{z+1}$$

where

LIW (e,a)	= lifetime income for a worker in the labour force with age (*a*) and education level (*e*)
LIS (e,a)	= lifetime income for a student in the labour force with age (*a*) and education level (*e*)
LINL (e,a)	= lifetime income for a member of the non-labour force with age (*a*) and education level (*e*)
AIW (e,a)	= current annual labour income of worker
AIS (e→ē,a)	= current annual part time earnings of student during study
EMR(LF) (e,a)	= employment rate in the labour force
SUR (a+1)	= survival rate
ENR(LF) (e→ē,a)	= enrolment rate at study level (ē) in the labour force
T	= study duration to qualify for education level (ē)
t	= year of study
z	= remaining years of study
g	= real growth rate of labour income
r	= discount rate.

Note that the denominator in the employment rate and enrolment rate is restricted to the labour force. For the remainder, Equations (4.2) and (4.3) can be read in the same way as Equations (2.2) and (2.3). In Equation (4.2) the lifetime income for a representative worker in the group (*e,a*) is equal to the sum of his or her current labour income (adjusted for the probability for work) and the present value of the lifetime income in the years after then (adjusted for the survival rate, income growth rate and discount rate). The latter is the sum of the second and third term of Equation (4.2), or the expected value of incomes resulting from the probabilities for study and no study.

Note the differences with Equation (2.3) of the common model in the income flows during study and after qualification for level (ē). In Equation (4.2) earnings during study are represented by part time earnings of students, while Equation (2.3) applies the lifetime incomes of representative individuals with education level (ē). Moreover, in Equation (4.2), just only after the year in which education level (ē) is achieved, the worker can earn the lifetime income at (*T+1*). In Equation (2.3), lifetime incomes are averaged across *T* (study) years.

For students in Equation (4.3) the probability for study is 100%, so the variable *ENR* does not apply. Furthermore, calculations are made on the *remaining* years of study (*z*). Note that the current annual income is the part time income of a student (*AIS*). Further, we calculate for each study year separately the lifetime income of the representative student. In the end we average these lifetime incomes over all study years, assuming students are equally distributed.[38] This we apply as the lifetime income of a representative student studying at level ($\bar{e}$).

We added Equation (4.4) for the non-labour force to the original model of Liu and Greaker (2009). The Dutch non-labour force comprises students who do not work and do not want to work (about 15%), pensioners (15%), individuals who receive a benefit or are on social security (30%), and a remainder (40%). Most of this 40% is female and low-educated. The other mentioned 60% may have some working experience or knowledge. We think that the human capital of the non-labour force has less value on average than that of the labour force. How much less, is subject to discussion. For now we assume that the human capital per capita of members of the non-labour force is (on average) half of the lifetime income of workers, which is a cautious estimate. Equation (4.4) represents this correction factor by $\lambda = 0.5$.

Non-labour force

$$(4.4) \qquad LINL_{e,a} = \lambda \times LIW_{e,a}$$

where

λ = factor determining the value of human capital per capita for non-labour force.

In the end, human capital per capita is added up across workers and students in the labour force, and the individuals in the non-labour force:

$$(4.5) \qquad HC_{WS} = \sum_a \sum_e LIW_{e,a} \times NW_{e,a} + \sum_a \sum_e LIS_{e,a} \times NS_{e,a} + \sum_a \sum_e LINL_{e,a} \times NNL_{e,a}$$

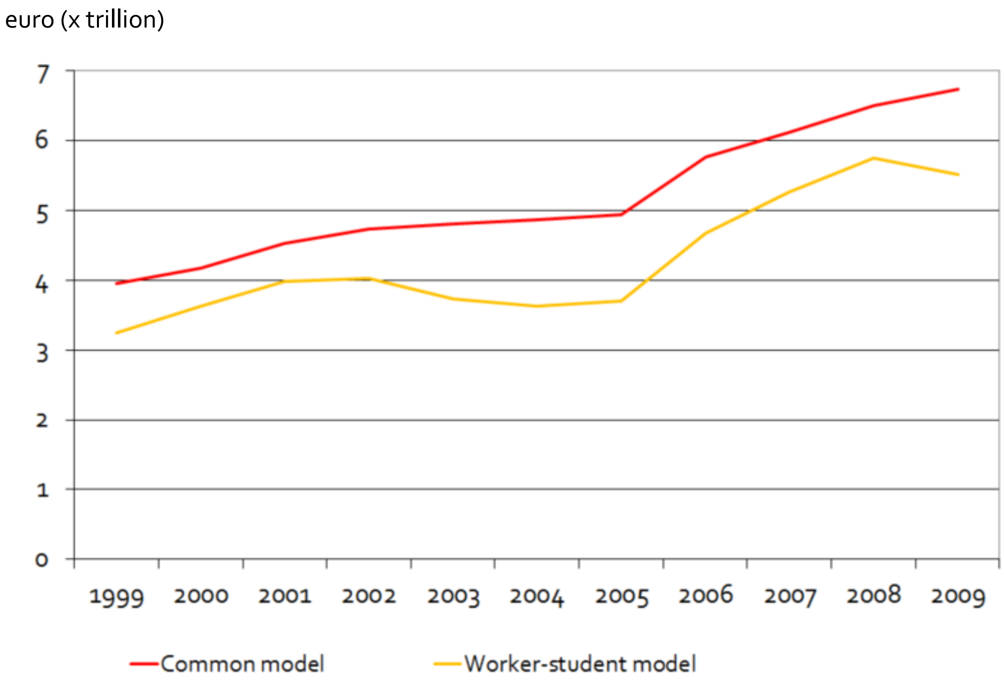
where

HC (WS) = national human capital stock according to the worker-student model
NW (e,a) = number of workers in group (*e*,*a*)
NS (e,a) = number of students in group (*e*,*a*)
NNL (e,a) = number of persons in non-labour force in group (*e*,*a*)
LIW (e,a) = lifetime income of representative worker in group (*e*,*a*)
LIS (e,a) = lifetime income of representative student in group (*e*,*a*)
LINL (e,a) = lifetime income of representative member of non-labour force in group (*e*,*a*).

Figure 4.3 compares the estimates by the worker-student model to those of the common model in Section 3. We see that the human capital stock estimates by the worker-student model are lower than that of the common model, but still sizeable. The main conclusion from both models is that human capital is several times larger than GDP.

[38] For that matter, the worker-student model makes the same assumptions as the common model: no drop out or delay in study, students are equally distributed, and students can only study at a higher level than their achieved education level.

Figure 4.3 Comparing two alternative applications of the lifetime income method: nominal value of human capital stock, 1999-2009



More interestingly, the volume growth of human capital is somewhat higher according to the worker-student model (0.47%) than the growth according to the common model (0.27%) (see Table 4.2, and also compare Figures 3.3 and 4.4). The difference is in the volume development of human capital per capita. This volume growth was positive in the alternative model, whereas it was negative in the common model. But both growth rates were very small in size (-0.06% and 0.14 respectively). In both models, the main growth source of human capital is population growth (0.33%).

Looking further into the human capital per capita development according to the worker-student model, we observe that the positive first order effect of education is somewhat larger than the negative ageing effect (Table 4.2). The volume developments in gross investments, depreciation and revaluation are presented in Figure 4.5 and Table 4.3. We see that net investments develop less negatively and revaluation grows more in the worker-student model than in the common model. The volume growth of depreciation due to ageing is higher but gross investments in education are also higher.

Nevertheless the main conclusion of the worker-student model is largely similar to that of common model. The ageing effect is apparently not firmly compensated by investments in education. This may indicate that the Dutch economy does not robustly fulfil the necessary condition for sustainable growth, namely a non-decreasing volume of human capital per capita over time. The worker-student model might be preferred to the common model, as the first model makes full use of the micro-data at hand (SSD). It should be investigated where the main quantitative differences come from (in level and volume growth).

Figure 4.4 Worker-student model: volume of human capital, human capital per capita, and population, 1999-2009

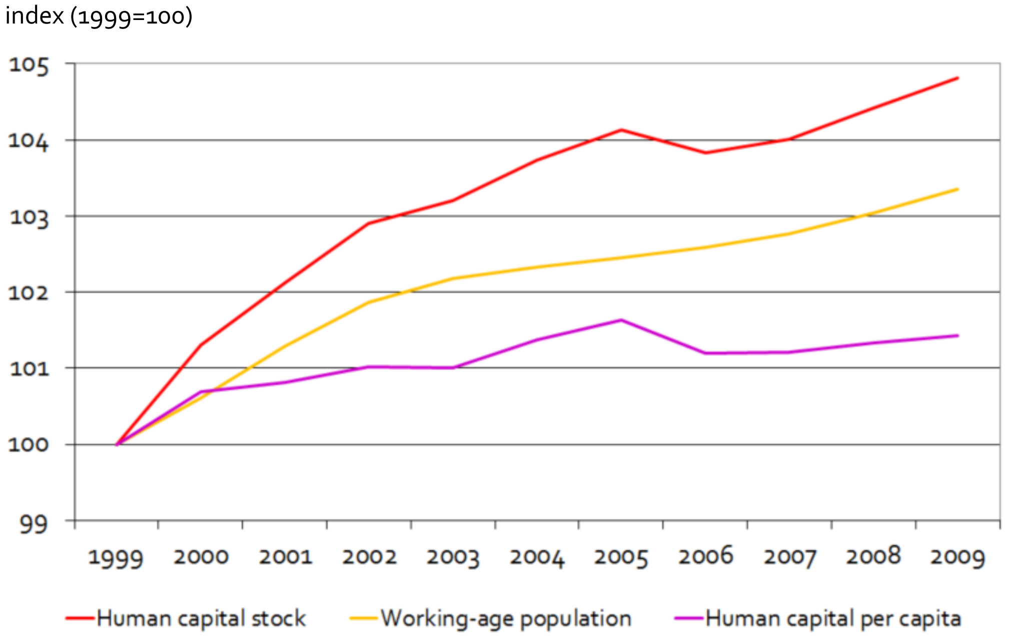


Table 4.2 Two alternative estimates of volume growth of human capital and first order effects on human capital per capita (average annual growth, %), 1999-2009

	Common model	Worker-student model
Human capital stock	0.27	0.47
of which		
... Working-age population	0.33	0.33
... Human capital per capita	-0.06	0.14
first order effects on human capital per capita		
... ... Sex	-0.03	-0.03
... ... Education	0.66	0.82
... ... Age	-0.65	-0.55

Note: the sum of the contribution of the characteristics differs from the overall change in human capital per capita, as the respective contributions are first-order approximations to the index of human capital per capita.

Figure 4.5 Worker-student model: volume development of gross investment, depreciation and revaluation of human capital, 2000-2009

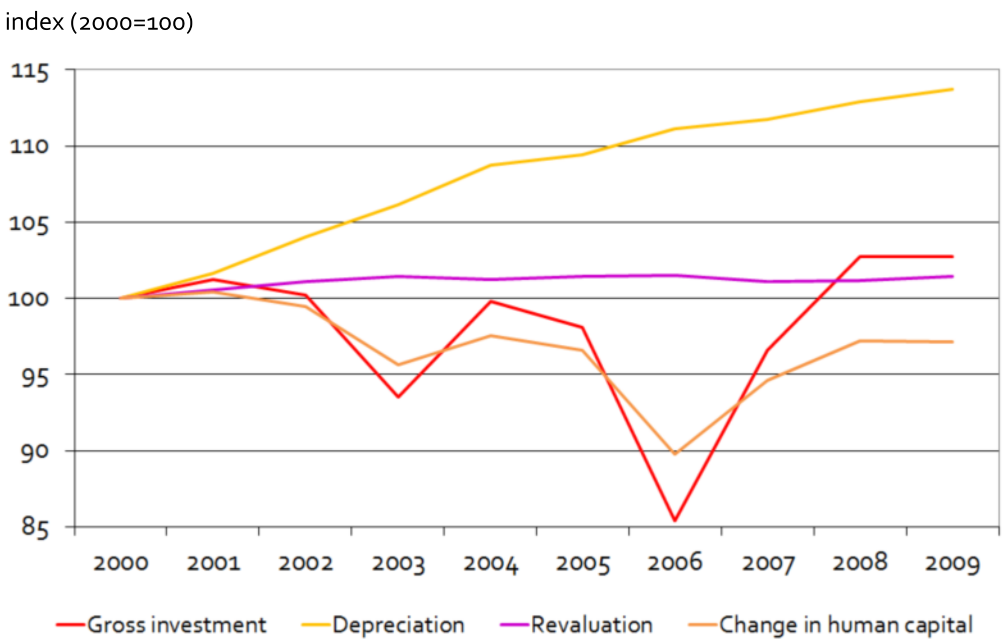


Table 4.3 Two alternative estimates of decomposition of volume change of human capital, 2000-2009

	Common model	Worker-student model
Gross investment in human capital	0.28	0.33
... Investments in education and immigration	0.36	0.42
... New workers (entry of 15-year olds)	0.20	0.21
Depreciation of human capital	0.94	1.51
... Ageing of population	1.03	1.62
... Decrease in number of workers (by death, emigration, retirement)	-2.44	-1.84
Net investment in human capital	-8.05	-7.88
Revaluation	0.00	0.14
Total volume change in human capital stock	-0.55	-0.36

4.4 Potential human capital

What is the 'human capital stock'? One may want to measure the human capital actually utilized (by the (self-)employed), 'available' human capital (of the working age population, as measured in Section 3),[39] or even 'potential' human capital. Currently there are many individuals who are working only part-time or are willing to do so. The Netherlands are known for the relatively high proportion of females who work part-time. If those individuals would work full-time or willing to do so, this would increase the available human capital stock. In such a view, there is a potential which is not utilized or will never be. Accounting for potential is not practiced in the national accounts, but the concept is interesting for theory and policy. Policy to encourage part-time workers to work more hours in a week might have a positive effect on the human capital stock. The size of this effect depends on the size of part-time work, on the personal characteristics (*s,e,a*) and wages of those who work part-time (besides the willingness of part-time workers to work more hours).

First we estimated a rough 'part-time factor' for each subpopulation (by sex, age and education level). This 'part-time factor' is the ratio of the number of hours worked by full-time employees to the average number of hours worked. The number of hours worked by full-time workers is derived from Dutch statistics on employment and wages (SWL), available from the data bank Statline of Statistics Netherlands. For example, the number of hours worked was 39 in 2007. The average hours of work per week are from the Dutch labour force survey (EBB) in Statline. These data are for the labour force by sex, 10-year age groups and three education levels (Low, Middle and High). In some subpopulations, however, the average number of hours worked is higher than or equal to the average of the full-time employees. In those cases, we fix the 'part-time factor' at 1. The estimated 'part-time factors' are applied to the different subgroups (*s,e,a*) at a lower aggregation level in our human capital database. We emphasize that these 'part-time factors' are rough estimates, which could be refined further to lower aggregation levels. Table 4.4 compares the estimated available and potential stocks in the period 1999-2009.

The estimates in Table 4.4 show that, if all individuals would work full-time, the volume of human capital would have been 9.0% to 9.5% higher. The annual growth rate of the potential stock (0.30%) does not differ much from that of the available stock. With a population growth rate of 0.33%, the average annual growth rate of potential human capital per capita -0.03%, comparable to the growth of available stock per capita (-0.06%, see Table 3.4). Potential human capital volume per capita develops as strongly as the available stock per capita does.

Realisation of such a potential by means of government policies would be not easy, because individuals may have compelling reasons to work part-time. Further, even if females would work more full-time, there would remain wage differences between males and females because of other factors, such as discrimination. This is one of the main disadvantages of the lifetime income method, which applies market wages as a proxy for marginal productivity.

[39] We label it as 'available' capital, as there is an on-going dynamics in the labour market status of individuals in the working age population (employed, unemployed and non-labour force), without sharp and static boundaries between the various subpopulations. Then one may assign lifetime incomes to each individual in this population irrespective of his or her status.

Table 4.4 Comparison of the available and potential human capital stock, 1999-2009

	Level of stock			Average annual growth (%)
	1999	2004	2009	1999-2009
Value, bln current euros				
Available stock	3949	4869	6743	
Potential stock	4303	5459	7550	
Volume, 1999 prices				
Available stock	3949	4038	4055	0.27
Potential stock	4303	4409	4434	0.30
Percentage difference between available and potential stock (volume)	9.0	9.2	9.4	

4.5 Linking to the National Accounts [40]

The System of National Accounts (SNA 2008) provides a coherent and consistent framework which is important for analysis. As is mentioned in Section 2.1, the SNA does not consider human capital as an investment good. Investment in human capital cannot be assigned to a third party ('third party criterion'), it is not tradable, and its ownership is difficult to determine. There is no market price for a product 'human capital'. Education and training (expenditures) are part of the SNA, but these are accounted for as (final and intermediary) consumption. Other investment such as working experience and health improvements are not accounted for at all. If investments in human capital could be put into the SNA framework, this would give many new opportunities for research and policy. Therefore there is increasingly more interest for research on human capital in a NA framework (Jorgenson, 2010; Fraumeni, 2011; Schreyer, 2010).

As the introduction of human capital as a capital good would change the NA core in a fundamental way, the construction of a satellite account human capital is the most appropriate route to link human capital to the main NA aggregates. In order to keep control over the complexity of the subject, the first design of such a satellite account should be restricted to the working age population and investments in human capital via education and training. Further we need a monetary measure of the output of human capital formation that satisfies principles of the SNA. The most well-known applications of such output measurement are the cost approach (Kendrick, 1976) and the income approach (Jorgenson and Fraumeni, 1989). The income approach is described in Section 2.2. The cost approach estimates tangible and intangible human capital on the basis of accumulated costs made in the past during the process of human capital formation. Tangible components are the investments needed for production of the physical human capital unit, such as the raising of children. Intangible investments lead to the increase of quality and productivity of labour: education, mobility and health and safety.

[40] This Section is an excerpt from Rensman (2013b).

If capital markets were perfect, both approaches would generate similar estimates (Le et al., 2003). In practice, the income approach estimates a human capital level which is different from the estimated level based on the cost approach. Usually the income method gives a substantially higher estimate than the cost method (Abraham, 2010). This is partially because of methodological and measurement problems. Both methods have their advantages and disadvantages, which are discussed by various researchers, among others Stroombergen et al. (2002), Le et al. (2003), Fraumeni (2008), Abraham (2010), and OECD (2012). Appendix B sums up the main issues.

At the input side (based on the cost method) not all relevant investment costs are accounted for, so this probably results in an underestimation. An important cost often not accounted for are the earnings forgone of students. If students are in the class or do their homework at home, they cannot use this time for working that would earn them an income. Their earnings forgone have to be considered as a private investment in human capital (Abraham, 2010; Bos, 2011).[41] This idea originates from Schultz (1960), and Kendrick (1976) accounted for these costs in his national accounts.

But probably the overestimation at the output side (by means of the income method) is a larger problem. Abraham (2010) argues that three main causes of overestimation of output are: not accounting for heterogeneity across individuals, not accounting for mutual influence between various types of investment in human capital (education, training, health improvements etc.), and wrong estimation of the real value of output. Further, assumptions on, for instance, the growth rate and discount rate have a substantial impact on the estimation of the human capital level, although an analysis of the *growth* of human capital may be plausible (see Section 4.1).

Nevertheless the simultaneous application of both methods may give much insight in the various elements in the production of human capital (OECD, 2012). The cost approach shows the expenditures by sectors in the economy (government, households, businesses), and possibly also the expenditures of non-market related inputs, such as time used for education. The income approach shows the importance of demographics (such as age and sex), education levels and enrolment in education, and factors related to the labour market (probability for work, incomes). The monetary figures have to be complemented with the measurement of volumes and prices, decomposition analyses and 'physical' indicators such as numbers of students enrolled.

Both the cost and income approaches assume implicitly a production process for human capital. However, in order to design a satellite account for human capital, its production process has to be described explicitly. What are the inputs and outputs of investments in human capital? What happens with output? There is still no common framework for this production process, based on the principles of the SNA, and which shows how the concepts of production and capital differ from that of the core NA. One of the few who explicitly describe the production process of human capital is Aulin-Ahmavaara (2004). He proposes a dynamic input-output model based on physical quantities (or individuals) by education level, and prices. Further he supposes two types of products, namely human capital and human capital services or 'human time'. In his opinion, human time is eventually the only scarce good of individuals.

[41] The estimation of these earnings forgone is another discussion. There are two common methods: opportunity costs (measurement by the wage an individual would have earned if he/she had been employed) or replacement costs (measurement by the wage of a generalist or specialist who replaces the individual).

This raises the issue whether human capital needs to be treated in the same way as conventional capital, as De Haan and Van Rooijen-Horsten (2003) argue. They think that measurement of human capital services is not necessary, because earnings already give a clear picture of the value of human capital in production.

Aulin-Ahmavaara (2004) compared the implicit production systems of the cost and income approaches with his own model. Both approaches do not account for certain inputs which are part of the input-output model. Particularly the costs of final consumption of ordinary goods and services are (largely) not accounted for by the cost and income methods as input in the production of human capital. This leads to very high returns on investments in human capital. The model of Aulin-Ahmavaara (2004) seems very simple but it goes against the SNA. In his model the primary input labour no longer exists, and all that is used up in the production of human capital should be considered as input, among other things the final consumption by individuals.

There are already a number of studies on the design of a satellite account human capital on the basis of a cost method. One example is Bos (2011), who considers education as investment by households and training as investments by firms. The value of investments in human capital is equal to the sum of expenditures on education and training, and opportunity costs. The latter are equal to the wage costs of employees who pursue a training and the earnings forgone of students during their study. Bos (2011) adjusted the standard supply and use table in a number of steps. First he breaks down products into characteristic products (education and training) and 'other products'. In the second step he assumes that labour compensation of employees is a payment for a product (education). Finally he assumes that expenditures to education and training are investments in human capital. Besides human capital formation there is also human capital consumption, of which the value is calculated with a PIM method.

A satellite account based on the income method does not exist yet. However Abraham (2010) mentions a number of basic elements in such a satellite account. According to Abraham (2010) the cost and income methods actually are parallel to two approaches of the output measurement in the NA, namely the income approach and production approach respectively. In the NA the compensation of factors of production (income) is in principle equal to the monetary value (production value) of sales of final demand. This implies the two are each other's benchmark. A similar structure of double-entry bookkeeping could be applied to the design of a satellite account of human capital. Such a satellite account would account for the investment costs (inputs) as well as the present value of returns to the investments (outputs). OECD (2012) also supposes that the cost and income methods may complement each other, although there will be relatively large problems with data and methodology (compared to a more simple satellite account based on the cost method alone).

In the satellite account according to Abraham (2010) the inputs would comprise costs of investments in human capital and auxiliary products. These are the costs of materials, salaries, and capital costs (of buildings etc.), the costs of time for studying by students etc. A part of these costs are already accounted for in the NA, and could be moved to the satellite account. The costs of time used by students have to be calculated via an opportunity cost method. The output of education (and possibly also training, see Jorgenson, 2010) is the improvement in competencies and skills which lead to a higher future return, or a higher labour productivity (represented by higher earnings). This output is valued by means of the income method of Jorgenson and Fraumeni (1989). The output is equal to the increase in lifetime incomes as a result of education and training. One may consider the net returns to education (gross return minus costs) as profits for the households, more or less parallel to the profits of the business sector.

Table 4.5 sketches the potential elements of a satellite account human capital in which input is valued at the costs of investments in human capital, and output at the increase of lifetime incomes. There will be more practical choices to be made: in data, assumptions and method; in volume measurement with indices (see also Abraham, 2010 and Fraumeni, 2011), and the measurement of quality changes (see Gu and Wong, 2012 and EC, 2011). The solutions to problems, particularly the investigation of causes of differences in estimates between the cost and income methods and the design of a general framework of the production process, will be important elements of the design phase of a satellite account for human capital. But according to many, such as Abraham (2010), the income approach is the most feasible method to measure the returns and productivity of education and training. OECD (2012) also recommends further research into the possibilities of a satellite account that is based on the income method.

Table 4.5 Potential elements in a satellite account human capital

Element	**Description**
Investments	Formal education and training on-the-job.
Inputs	Based on cost approach. Costs of education, school buildings, students' time use and time use of employees etc.
Outputs (characteristic products)	Based on income method (lifetime income) or some other pricing method.
Auxiliary activities	E.g., O.a. transportation of commuters and students, production of study books.
Producers (new industries)	Employees/workers, unemployed/not working, students.
Beneficiaries	Households (education) and firms (training)
Financing (transfers and other)	Government (education), firms (training), households (earnings forgone students, schooling costs etc.), non-profit sector serving households (education).
Tables	Production (SUT), expenditures, income, financing, non-monetary figures
Monetary figures	Inputs: Expenditures to education and training by functional classifications (in core NA), accounted for in satellite account as investments and broken down by education level. Outputs: Calculation lifetime incomes with micro-data.
Non-monetary figures	Demographics, earnings, hours worked, employment, survival rates. All data broken down by sex, age and education level.

5. Conclusions

This report estimated the size and change of human capital in the Netherlands in the period 1999-2009. The estimates were based on the lifetime income method. We restricted the estimation to the working age population and formal education financed by government. Our main findings are as follows:

- The value of the human capital stock in the Netherlands was several times larger than that of natural and physical capital, and GDP. Compared to other countries, the human capital – GDP ratio is apparently relatively low. Males, youngsters and higher educated individuals appear to contribute most to the human capital stock. These conclusions are valid for both the common empirical variant applied in Section 3 and the worker-student model in Section 4.3.
- The volume growth of human capital was substantially lower than that of other types of capital, and Dutch human capital growth was relatively low in international perspective. The volume growth was positive mainly because of the population growth. The volume growth of human capital per capita, however, was around zero. Depending on the empirical model applied (common model or worker-student model) there was a small negative or a small positive growth. In any case, the ageing effect is apparently not firmly compensated by investments in education. This apparently indicates that the Dutch economy does not robustly fulfil the necessary condition for sustainable growth, namely a non-decreasing volume of human capital per capita over time.

The results of the common model were compared with those of the worker-student model. As we mention above, the main conclusions are similar. The worker-student model might be preferred to the common model, as the first model makes full use of the micro-data at hand (SSD). It should be investigated where the main quantitative differences come from (in level and volume growth).

Another discussion on the plausibility of the lifetime income method was on the sensitivity of the estimates for assumptions on the discount rate and income growth rate. The analysis shows that these affect the level estimates, and to a much lesser extent growth rate estimates. Further we estimated a benchmark model based on the share of labour compensation in GDP. The discussion indicates that the lifetime income method gives plausible results, in that the human capital stock is several times larger than GDP. Further we made a rough estimate of the 'potential' stock, in case of which all individuals (are willing to) work fulltime. This potential stock appears to be about 9 to 10% higher than the 'available' stock (in volume terms).

We finally discussed about the linking of human capital estimates based on the lifetime income method to the System of National Accounts (SNA). Up to now expenditures to education and training are accounted as final or intermediary consumption in the SNA. However, monetary measurement of human capital as an investment good would increase the usefulness of the SNA for analysis and policy. It would give a better productivity measurement, a more complete national wealth account, new main aggregates useful for discussions on sustainability (Statistics Canada, 2011). There are also increasingly more policy questions on the societal impact of human capital investments, such as the distribution of human capital across households (Gu and Wong, 2012; OECD, 2012).

SNA 2008 (A4.55) states: 'Human input is the major input in most production processes, and the value of that input is to a large extent dependent on the knowledge that humans bring to the production process. It is well recognized that an educated population is vital to economic well-being in most countries. Despite the fact that there are major conceptual and practical problems with identifying the value of an educated labour force, there are repeated requests to address this issue within the SNA framework.' In the second half of 2013, OECD and UNECE establish a new Task Force Human Capital (with participation of Statistics Netherlands) that will, among other things, investigate the design of a satellite account human capital during a research period of 3 years. This emphasizes the importance attached by many statistical institutes to the introduction of human capital investment into the SNA framework.

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Appendices

A. Driving factors of human capital formation

According to the theoretical literature, there are many factors which contribute to the formation of human capital, and not all factors are measured adequately (yet). Table A.1 shows a list of these factors. There are not only many factors, but the factors are also important for more than one aspect in the life of individuals, and the factors overlap each other and affect each other. For instance, 'learning' does not occur not only in education, but also within firms (on-the-job training) and outside the market (such as in the raising of children). Mutual influence of factors is observed, for instance, in that individuals with higher abilities have higher probability to choose for higher education, and in that higher educated individuals will invest more often in the improvement of their health.

Table A.1 Factors affecting human capital formation

1. Demographic changes
    a. Emigration and immigration
    b. Births, deaths
    c. Entry to the labour force or reaching working age (15 years)
2. Education
    a. Formal general education
    b. Formal vocational education
    c. Other formal education, e.g. adult education
    d. Informal education or learning
3. Employment
    a. On-the-job training
    b. Working experience
4. Other time use (non-market activities)
    a. Maintenance (sleep, eat, etc.)
    b. Investment in healt
    c. Household production
    d. Caring, raising and teaching others (e.g., children)
    e. Leisure time (e.g., volunteering, recreation)
5. Non-reproducible / non-observable factors
    a. Innate capacities
    b. Social background
    c. Market imperfections (e.g., rigidities due to collective labour agreements)

According to De Haan and Van Rooijen-Horsten (2003), non-reproducible factors cause measurement problems. In their opinion, investments (education, training etc.) lead at the most to 'improvements' of human capital. Then the capitalisation of investments will not be the same as measurement of human capital. EC (2011) argues that non-observable factors may lead to a bias in the estimates of returns to education. If, for instance, individuals with more abilities convert education into human capital more efficiently, then the estimated returns will be biased upwards. But it is important for policy makers that investments (in education, training etc.) can be influenced and therefore a measurement of these investments and their outcomes (an improved education level, better health etc.) will be meaningful in an analysis. The population may also be broken down into different levels or categories of a non-reproducible factor in order to picture the distribution of human capital. How one may quantify or classify such a non-reproducible factor, is a separate issue. For instance, social background can be pictured with figures on the composition of households, ethnic background or place of residence.

B. Advantages and disadvantages of cost and income methods

Cost approach (Kendrick, 1976)

Advantages
- In line with valuation of economic capital in NA, according to a PIM method (although some capital goods in NA are also valued with a present value method)
- Relatively easily applicable because of availability of data

Disadvantages
- Supply-side estimation; does not measure size of investment in human capital as a result of interplay of demand and supply
- Based on costs in the past, does not give any indication of human capital in future
- Output is equal to value of costs of inputs
- Does not clearly differentiate between expenditures as consumption and expenditures as investment
- Does not take into account the (sometimes long) time lag between expenditure and the resulting output of human capital
- Determining price index difficult (index needed for valuation of current stock based on a PIM method)
- Determination of depreciation rate is rather arbitrary.

Income approach (Jorgenson and Fraumeni, 1989; 1992a; 1992b)

Advantages
- Consistent with economic theory, relationship with productive capacity needed for future production
- Application of labour earnings as proxy for the price signalling the value of human capital services as a result of interplay of demand and supply
- Estimates output independently of input
- Relatively easily extended to an accounting system with values, volumes and prices

Disadvantages
- Labour earnings assumed to be equal to marginal productivity of individual; this is a strong assumption as earnings are affected by fact that markets are imperfect with institutional rigidities and hidden external factors (social background, innate abilities etc.)
- Usually applies synthetic cohort data based on cross-Section data
- Determination of exogeneous discount and growth rates are problematic regarding the estimation of the level of human capital (to a lesser extent for growth of human capital)
- Does not account for heterogeneity across individuals (some would be better off if they would have continued working instead of pursuing an education programme)

- Does not account for mutual influences between various types of investments (formal education, training, working experience etc.), resulting in overestimation of contribution of formal education to human capital output

Both approaches

Advantages
- Human capital is considered as an investment good. Meets accounting principles for a capital good (price, volume, life duration, depreciation, revaluation etc.)
- Practically feasible, although with assumptions due to lack of data, have to make many practical choices

Disadvantages
- Data requirements are large so that many assumptions have tob e made; lack of data for types of investments other than formal education, but also lack of data for formal education itself (e.g. break down by education level is too rough)
- Still no common consensus on many elements, e.g. population, part time work, etc.
- Estimation of non-market activities (such as health improvements) and valuation of human capital of children and elderly still problematic
- No valuation of external effects such as knowledge spillovers
- Do not account for a large part of intermediary inputs, resulting in very high returns to investments
- No (conceptual) differentiation between consumption and investments
- Need assumptions for calculation of real values (volume indices).

C. Choice of growth and discount rate

As mentioned in Section 3.1, we applied a real income growth rate *g* of 1.63%, being the average annual growth rate of real labour compensation per hour worked in the period 1969-2010, and a discount rate *r* of 4.58% from Jorgenson and Fraumeni (1992a). These values were chosen from a number of possible alternative values. Table C.1 lists these alternatives.

First, the real income growth rate *g* can be measured with labour productivity growth, or growth of gross value added (gross domestic product at national level) per hour worked or per full-time equivalent. This measure is applied by other researchers on human capital measurement, for instance Gu and Wong (2010). However, labour productivity growth is partially related to physical capital deepening. So it might not be the best measure for the real income growth rate *g*. A more preferable alternative is to measure *g* with the real earnings per labour volume unit, such as done by among others Liu (2011). We chose to measure *g* by the average growth in real earnings per hour worked, which gives 1.63%. As this value is in between the values of the abovementioned alternatives, we think it is a reasonable value for *g*.

Measuring the discount rate is more difficult, as it implies knowledge about future. The discount rate reflects two elements. First, it represents the time value of income. This is the idea that money available now has more value than money in the future because it can generate interest or return. The time value of money can be measured by capital cost, e.g., an interest rate. But the discount rate also encompasses risk. This risk follows from the uncertainty about expected future income flows, which might be lower than expected. Hence the discount rate might be higher, namely the capital cost raised with a risk premium.

Table C.1 Alternative values for real income growth rate (*g*) and discount rate (*r*)

Indicator	Data source	Sample period	Value
Real income growth rate			
G.1 Average annual growth rate of real value added per hour worked	National Accounts, volume gross domestic product; Labour Accounts, hours worked by persons employed	1969-2010	2.08%
G.2 Average annual growth rate of real value added per fte	National Accounts, volume gross domestic product; Labour Accounts, fte of persons employed	1969-2010	1.81%
G.3 Average annual growth rate of real earnings per hour worked	Labour Accounts, compensation and hours worked employees; Consumer Price Index	1969-2011	1.63%
G.4 Average annual growth rate of real earnings per fte	Labour Accounts, compensation and fte employees; Consumer Price Index	1969-2011	1.27%
Discount rate			
R.1 Average real long-term interest rate	Average interest rate on the five longest-term bonds (till 2002); linked to interest rates on 10-years government bonds (from 1999 onwards, data from Dutch Central Bank); Consumer Price Index	1969-2011	3.02%
R.2 Social discount rate	Ramsey model World Bank (2006); real growth of per capita consumption	1969-2010	3.31%
R.3 Jorgenson-Fraumeni discount rate	Jorgenson and Fraumeni (1992a), estimated rate of return on long-term investments in the private sector of the USA.	--	4.58%
R.4 Average real long-term interest rate with premium for risk	See R.1 for data sources. Risk premium calculated as standard deviation (2.05%), which is added to the rate R.1	1969-2011	5.07%

In Table C.1 the abovementioned idea is represented by an average real long-term interest rate without and with a risk premium (R.1 and R.4). The long-term interest rate is measured by the rate of return on long-term government bonds, with an average value of 3.02% (R.1). It is possible to measure the discount rate with other interest rates, such as the Central Bank lending rate which banks use when lending to each other. For the time being we chose the government bond interest rate, such as many other researchers on human capital measurement did.

We measured the risk premium on this long-term interest rate by the standard deviation from the mean:

$$\text{(C.1)} \quad t = \sqrt{\frac{\sum_{j=1}^{N} \left(r_j - \bar{r}\right)^2}{N}}$$

where t = risk premium, r_j = long-term interest rate in year *j*, $\bar{r}$ = average long-term interest rate in sample period (3.02%), and N = number of years in sample period. This gives a value of 2.05%, and a discount rate of 3.02 + 2.05 = 5.07%, being the value for R.4 in Table C.1.

Table C.1 presents two further alternatives for the discount rate. The first one is a social rate of return (R.2), calculated on the basis of the Ramsey model of the World Bank (2006). This model calculates national wealth *W* as

$$\text{(C.2)} \quad W_t = \int_t^{\infty} C(s) \cdot e^{-r(s-t)}$$

where $r = \rho + \eta \cdot \dot{C}/C$ is the social rate of return from investment. The pure rate of time preference ρ is assumed to be 1.5%, the elasticity of utility with respect to consumption η is assumed to be 1, and consumption growth $\dot{C}/C$ is constant. In the sample period the real per capital consumption growth is 1.81%. This gives a social rate of return of 1.5% +1.81% = 3.31%.

The last alternative is the Jorgenson-Fraumeni discount rate of 4.58% (R.3). As mentioned earlier, this is an estimate of the long-term real interest rate in the private sector of the US. The estimate is used by Jorgenson and Fraumeni (1992a) and is based on estimates in Jorgenson and Yun (1990). One may dispute this value as it is estimated on the basis of US data and on data from the past. But it has been applied for other countries, such as Liu (2011) and Li et al. (2012) did. We also chose this value, being in between the other alternatives, to avoid an extreme value for the discount rate.

To sum up, the values for the real income growth rate *g* (1.63%) and the discount rate *r* (4.58%) are carefully chosen as being in between the higher and lower alternative values described above. The sensitivity analysis in Section 4.1 shows that a higher or lower rate has an effect on the level of the real human capital stock, but no or only a very small effect on the growth rate of this stock. Further discussions on the choice of growth and discount rates can be found in studies by, for instance, Fraumeni (2011), Christian (2011) and Abraham (2010).

D. Laspeyres volume index

Various studies on the lifetime approach applied the Törnqvist index to construct the volume of human capital stock and investment (e.g., Liu (2011) and Gu and Wong (2010)). However, we follow the common practice in the National Accounts of Statistics Netherlands and apply the Laspeyres volume index.

An advantage of the simple arithmetic Laspeyres index is that its interpretation is simple, in contrast to the multiple geometric Törnqvist index. The Laspeyres index also satisfies the requirement on consistent aggregation, where the Törnqvist index does not.[42] Further, the Törnqvist index (in terms of logarithms) cannot deal with negative values, which arise in the prices and quantities of the components of investment in our data. Data calculations show that there were only small differences between the Törnqvist (where available) and Laspeyres.[43]

[42] See Van der Grient and De Haan (2011) on indices (in Dutch).

[43] The same applies for the Paasche and Fisher indices (except for gross investment in human capital in 2005 and 2006, where the differences are somewhat larger).

Following Van der Grient and De Haan (2011), we calculate the Laspeyres volume index Q_H of, for instance, the human capital stock H as the sum of the weighted simple quantity indices of the number of individuals (N) in the groups (s,e,a) at time t, with 0 (zero) as the base year:

$$\text{(D.1)} \quad Q_H^{t/o} = \frac{\sum_{s,e,a \in H} LI_{s,e,a}^{o} N_{s,e,a}^{t}}{\sum_{s,e,a \in H} LI_{s,e,a}^{o} N_{s,e,a}^{o}} = \sum_{s,e,a \in H} w_{s,e,a}^{o} \left(\frac{N_{s,e,a}^{t}}{N_{s,e,a}^{o}} \right)$$

where LI is the lifetime income for a representative individual in the group (s,e,a) or the price component of the stock, and N is the number of individuals in group (s,e,a) or the quantity component. The lifetime income LI is calculated by the algorithms in Section 2.2 (or 4.3).

The weight w^0 is the share of group (s,e,a) in the nominal value of the human capital stock in the base year 0:

$$\text{(D.2)} \quad w_{s,e,a}^{o} = \frac{LI_{s,e,a}^{o} N_{s,e,a}^{o}}{\sum_{s,e,a \in H} LI_{s,e,a}^{o} N_{s,e,a}^{o}}$$

This volume index increases if the composition of the population shifts to groups (s,e,a) with a higher lifetime income. This occurs, for example, if more individuals have a higher education level, or if more young individuals enter the population.

The human capital volume index per capita is the ratio of Q_H and the index for population N. Further, we can derive the (Paasche) price index for the human capital stock H by dividing the value index of the stock by the Laspeyres volume index.

E. Future research issues

The lifetime income method is theoretically the most sound and practically the most feasible approach, as was concluded by the participants of the OECD / Fondazione Giovanni Agnelli – workshop on human capital measurement in Turin in 2008. However, many improvements, refinements and extensions in model, data and assumptions are conceivable. There are issues which could be tackled relatively easily, and other issues which can only be solved with further research. Section 4 elaborated on some of the issues. In this Appendix we list desired changes in the application of the lifetime income method and extensions of the analysis in the current report.

Model

1. Application of different empirical variants of the lifetime income method and investigating the causes of differences in estimates (cf. Section 4.3).
2. Investigation of the fast decrease in lifetime incomes of lowly educated youngsters (see Figures 2.5 and 2.6)
3. Investigate to what extent the lifetime income method implicitly takes future study programmes into account (see Section 2.3).
4. How could earnings forgone due to studying be classified as depreciation on human capital, or at least measured separately (see Section 2.2.2)?

Population

1. Application of alternative definitions (e.g., the labour force and unemployment based on data from the Dutch LFS (or EBB)).
2. Investigation of alternative assumptions on the valuation of human capital of subgroups in the population, such as Individuals in the non-labour force without working experience, and pensioners. In the common model (see Section 2.1 and 3.2), these individuals were attached the same lifetime income as individuals in the labour force (by subpopulation *s,e,a*). But one might suppose that individuals without working experience have embody human capital valued at the lifetime income of individuals aged 15 while annual incomes do not change any more during the remaining working life span. Pensioners do have working experience, but the increase or maintenance of this experience comes to a halt when they retire, and may eventually decrease in value. One might assume, for instance, a lifetime income based on annual income that do not change any more after retirement.

Data sources

1. Extending the human capital time series beyond 2009 and before 1999, which will pose new data problems. For instance, the Dutch LFS (or EBB) data relevant for human capital estimation go further backwards (to 1987) than SSD data (available from 1999 onwards). Aggregated EBB data on the labour force by sex, age groups and three education levels (see Lodder, 2011) might be applied to extrapolate our time series backwards to 1987. The time series resulting from such a backward extrapolation will be a rough estimation of the change in human capital in the period 1987 to 1999. At the same time, one might extend the time series forwards to 2012 based on SSD data. It would be interesting to compare research conclusions based on the current time series of 1999-2009 (11 years) with those based on a substantially longer time series of 1987-2012 (26 years).
2. Investigation of alternative data (e.g., EBB), and comparison with the current results in Section 3.
3. Investigating the possibility of applying cohort data in the near future. We applied contemporaneous data of subpopulations with another age and education level to 'predict' incomes. However, there may occur cyclical or structural changes in the future causing future incomes to be lower or higher. Wei (2008, 2009) applied cohort data for Australia to calculate moving averages of incomes.

Data calculations

1. Investigation of an alternative break down into different education levels, particularly at higher education levels.
2. Exploration of alternative calculations of the probability to have a job or studying, e.g., filtering out cyclical fluctuations from the probability to have a job by applying a long-run average instead of annual figures.
3. Exploration of volatility in the data or lack of data, and the desirability for smoothing or imputation.

Assumptions

1. Explore alternative assumptions on discount rate *r* and real income growth rate *g* and their plausibility (see Appendix C).
2. Investigate adjustment of assumptions about studying (drop out, delay, allocation of number of students through the years of an education programme, study durations).

Extensions

1. Additional measurements, e.g.:
    - Measuring human capital stock and investment by occupation, sector, and/or geographic location.
    - Measuring types of investment in human capital other than formal education funded by government, starting with training-on-the-job and working experience. Some data on investment by means of firm training are available for the Netherlands (Statistics Netherlands, 2012). Working experience might be measured by (discounted) wage differences between age groups (see Wei, 2008).
    - Measuring returns to education and productivity of the education sector.
2. Additional analyses, e.g.:
    - Research on the low international ranking of the Netherlands with respect to the relative size of its human capital stock (see Section 3.1). Is the low ranking caused by (problems in) the applied model, data or assumptions, or by real socio-economic factors, such as relatively low investments in education?
    - Impact of changes in, for instance, an increase of the age of retirement, or a decrease in the share of part time work for the benefit of more fulltime work (cf. Section 4.4).
3. Application of the framework of the National Accounts:
    - Research on the linking of the lifetime income estimates to the National Accounts framework by means of a satellite account "human capital" (see Section 4.5).
    - Exploration of the methods for calculation of volume-indices for human capital stock and investment (see Appendix D).