WORKSHOP ON THE MEASUREMENT OF HUMAN CAPITAL

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TURIN
3 - 4 NOVEMBER 2008

SUSTAINABLE DEVELOPMENT AND CHANGES IN NATIONAL WEALTH FOR NORWAY IN THE PERIOD FROM 1985 - 2007

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Item 2.2

[*]This paper discusses the role of human capital measurement for sustainable development indicators and is presented as further background to the other paper in this item prepared by Mads Greaker and Gang Liu: 'Measuring the stock of human capital for Norway: a lifetime labour income approach'.

Sustainable development and changes in national wealth for Norway in the period from 1985 to 2007

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Oslo October 2008

1. Introduction

The UN Report "Our common future" (1987) defines *"sustainable development"* as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*. This definition is normally interpreted along two dimensions: One intra-generational and one inter-generational. The intra-generational dimension refers to the current distribution of income in the world, while inter-generational dimension is about the distribution of income between generations, that is, between generations living now and future generations.

This paper focuses on the inter-generational aspect of sustainable development. One possible interpretation of *"sustainable development"* from a pure inter-generational perspective is that the level of *consumption* in any particular year should not exceed the level making it possible to maintain the same level of *consumption* in future years. Clearly, the understanding of the term *consumption* should ideally be comprehensive, for instance, it should encompass both consumption of material goods and non-material goods such as natural amenities etc.

Given this interpretation of sustainable development, the question becomes how to know whether we are consuming too much. Different sets of indicators have been proposed in order to answer this question. One approach is the so-called *capital approach to sustainable development*; see e.g. Moe (2007). Since "consumption" must be "produced" every year from the use of inputs of which we have certain stocks, we need to monitor the current state of the stocks of inputs, henceforth, the capital stocks. The capital stocks together are denoted *national wealth*, and the task becomes to ensure that *national wealth* is kept intact.

The first purpose of this paper is to describe how *national wealth* is calculated by Statistics Norway. For several years we have followed a three-step procedure in order to calculate national wealth based on national accounts data (NA). Further, we present figures for national wealth in the period from 1985 to 2007. The figures show that national wealth is increasing throughout the period, which is an indication of sustainability. However, there might be flaws in the methods used that masks unsustainable practices. Thus finally, the third purpose of the paper is to discuss and suggest improvements of the method that has been used so far.

The understanding of national wealth should ideally also be comprehensive, that is, national wealth should encompass all types of capital that contribute to human well being. Capital stocks can be divided into stocks that *easily can be given an economic value*, and stocks for which this is controversial or difficult. Both should be viewed as subsets of the concept national wealth. In this paper we will focus on the former subset, in particular, the subset that can be given an economic value from available economic statistics. From now on we will refer to this as national wealth even if this definition of national wealth is clearly not comprehensive.

When the capital stocks can be given an economic value, keeping national wealth intact does not necessarily imply keeping each stock of capital intact. In fact, national wealth can likely be increased by running down some stocks of natural capital in exchange with other types of stocks. Keeping national wealth intact or increasing it by exchanging natural capital with humanmade capital is referred to as *weak sustainability*, see e.g. Harris (2002). It requires that natural and humanmade capital are generally substitutable. On the contrary, taking the *strong sustainability* approach, we would keep separate accounts for natural and humanmade capital, and ensure against depleting overall natural capital stocks.

Statistics Norway occasionally calculates Norwegian national wealth, and each time we follow a specified procedure in order to facilitate comparison of wealth estimates for different years. Our definition of national wealth only includes the inputs used to produce net national income (NNI) as measured and defined in the national accounts. These comprise inputs from natural resource stocks, human capital stocks, physical capital stocks and financial assets.

While both the value of physical capital and foreign financial holdings is given directly in the national accounts (NA), the values of the natural resource stocks must be computed. We calculate income and extraction costs associated with each resource stock, and evaluate the lifetime of each resource stock. The contribution of each resource stock to national wealth is then given as the present value of the future stream of net incomes. The resources included are the renewable natural resources; land, forestry, fisheries and hydropower, and the nonrenewable natural resources; oil, gas and mining.

Lastly, we calculate the value of the human capital stock. With human capital we are referring to the education, skills and experience of the labor force. In order to get to the value of the human capital component, we decompose NNI using the streams of income from the other wealth components. The residual, or the unexplained part of NNI, is set equal to the stream of income from the human capital component. Moreover, the value of this component is set equal to an infinite stream of the residual.

Despite Norway being very rich in natural resources, our calculations show that human capital is by far the most important component of Norwegian national wealth. For instance, in the calculations we carried out in 2007, we found that human capital comprised 75 percent of national wealth, while oil and gas and physical capital comprised approximately 10 and 12 percent, respectively. The contribution of the renewable natural resources taken together was around 0 percent. Furthermore, we showed that even if the value of the oil and gas resource stock fell by NOK 211 billion from 2006 to 2007 due to extraction, national wealth per capita increased because the value of the human capital component was increased by NOK 1993 billion.

Clearly, the method of calculating the human capital component is chosen mainly because it is simple. However, since human capital comprise the larger share of national wealth, it seems reasonable to devote more resources to the calculation of current and future returns from this component. For instance, the national wealth calculations would be far more interesting if the calculation could be used to explain why the human capital component was increasing or in some years, decreasing. Thus, when discussing possible improvements in the method by which national wealth is calculated, we focus on the human capital component.

2. Background

There exist a large literature discussing the theoretical foundations of national wealth accounting, and we will not venture into this literature here, but only mention a few central contributions. The book Limits to Growth by Meadows et al (1972) initiated the early literature. In Limits to Growth the authors predict that the world will run out of nonrenewable resources, and that the world population will collapse through famine and other disasters. Economists in general were very skeptical to the method employed in the book and to its predictions, and a strand of literature followed discussing whether production with nonrenewable resources eventually would mean doom, see for instance Dasgupta and Heal (1979). The literature culminated in the seminal article by Hartwick (1977), which shows what came to be known as Hartwick's rule: In an economy with a finite amount of a nonrenewable natural resource essential for production, investing each year exactly the resource rent from depletion in physical capital will achieve constant consumption over time. Since physical capital and the depletable resource are the only inputs to production in the model of Hartvick, the rule also reads as "zero net investment forever results in constant consumption forever". Zero net investment seems to imply no changes to national wealth, and hence, Hartvick's rule should be compatible with the above-mentioned prescription to keep national wealth intact.

Solow (1986) shows this formally, that is, Hartvick's rule implies maintaining aggregate wealth or "some appropriately defined stock of capital … including … resources" at a constant level over time. As noted by Lars Svensson (1986) in the commentary to Solow's article, Solow assumes a constant interest rate, while in the model of Hartwick the interest rate is steadily declining due to less resource extraction and increasing capital accumulation. With a declining interest rate, wealth must be increased in order to keep the return from wealth constant, see Brekke (1997). On the other hand, since Norway is a small open economy, we can assume the interest rate to be given from abroad and constant. Accordingly, Brekke (1997) shows that in a small open economy with access to a perfect capital market, non-declining wealth is consistent with sustainable consumption (see also Solow, 1993).

The literature applying sustainability criteria to national account numbers is scarcer. Pearce and Atkinson (1993) was an early contribution tracking net investments or as it has come to be called, *genuine investment*, in 18 different countries. The genuine investment indicator can be seen as a direct application of Hartwick's rule. Applying Hartwick's rule strictly would imply that none of the resource rents could be consumed, that is, all resource rents must be reinvested and *not* consumed! As mentioned above, for an open economy this is not necessarily so since future resource rents adds to your wealth, and the return on your resource wealth can be consumed. In particular, Sefton and Weale (1996) show that it is the return from the part of a country's resource wealth that is exported that is available for consumption.

Later contributions are for instance Hanley et al (1999) and The World Bank (2005). Hanley et al compare different sustainability indicators, among others genuine investments and green national product, for Scotland, and found that the indicators lead to different conclusions. The World Bank looks at genuine savings for as much as 140 countries. They include investments in human capital by counting expenses for education as a positive investment, and they find that the level of genuine investment is positive for developed countries, but not for all developing countries.

While most of the applied literature seems to focus on genuine savings as the sustainability indicator, Statistics Norway has continued to calculate and monitor national wealth. In Norway a commission was established in 2004 to put forward a proposal for a set of indicators for sustainable development, and they delivered their report in 2005 entitled "Simple signals in a complex world" (NOU 2005). In order to create a unifying framework, the commission chose to base the indicator set on *national wealth*, and to broaden the concept compared to how it has traditionally been used at Statistics Norway.

The definition of national wealth used by the commission not only includes resources that have a market value, but also natural and environmental resources that not so easily can be valued in money terms (see for instance Moe, 2007 and Alfsen and Greaker, 2007). Moreover, the commission recommended that some natural resources were reported both in physical and monetary terms. This could be seen as a step towards strong sustainability. Clearly, even if the monetary value of national wealth increases, we risk being on a non-sustainable development path if critical natural capital stocks are seriously depleted. We will not venture further into the discussion about strong versus weak sustainability here, just remind the reader that the focus in this paper is the part of national wealth that can be given an economic value, and that by adding the monetary value of different capital assets we are in practice applying the concept of weak sustainability.

From the beginning the issue *sustainable development* and the concept of *weak sustainability* was tightly linked to resource management, and to what extent depletion of all kinds of non-renewable natural resources could be exchanged for increased levels of physical capital. The notion of human capital has later been introduced as an alternative investment prospect for resource rents. However, the measure of human capital is more difficult since human capital is intrinsically linked to persons, and cannot be bought and sold in asset markets. In order to frame our discussion we start with a detailed description on the procedure currently used by Statistics Norway to calculate national wealth.

3. Current practise of calculating national wealth

The value of a resource stock is defined as the present value of the income stream accruing from it. In calculating this value all user costs of other resources in order to obtain the income must be subtracted. With respect to the different types of natural resources the income is coined *resource rents*. National wealth is calculated in three steps:

3.1 Step 1: Calculating resource rents

The resource rents are the additional income a nation/region obtains from having the exclusive right to exploit a natural resource. With point of departure in the national accounts, Eurostat (2001) and SEEA-2003 defines resource rent in the following way:

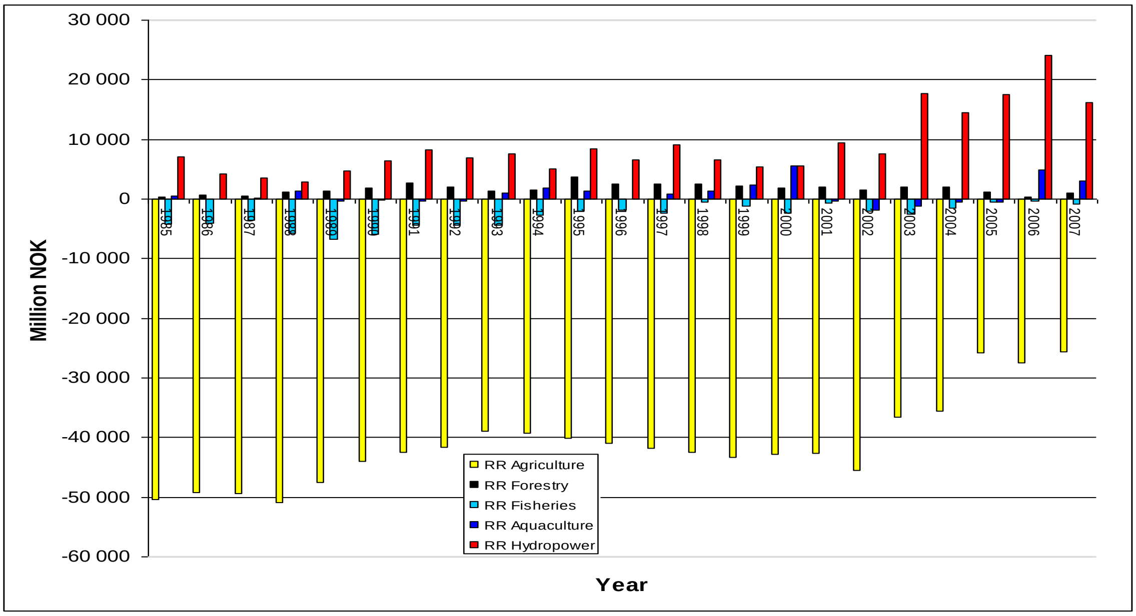
Resource rent =
I) + Basic value of output/production
II) - Intermediate uses
III) + Taxes on products
IV) - Subsidies on products
V) - Non-industry specific taxes
VI) + Non-industry specific subsidies
VII) - Compensation of employees
VIII) - Return on fixed capital
IX) - Capital consumption

When calculating compensation of employees and return to fixed capital, the idea is to use wage rates and rates of return that reflect the *alternative value* of both the workers and the capital employed to extract the resource. At Statistics Norway we have used the *average* wage rate for all non-natural resource industries as the *alternative* value of labour. Then, in order to calculate the compensation of employees in the natural resource sectors, we multiply the average wage rate from the non-natural resource sectors with the number of hours worked in each natural resource sector.

For the alternative value of capital we have either used 4 percent rate of return, or we have used the *averag*e rate of return to capital for all non-natural resource industries in Norway. The latter can be calculated from the operating surplus of the industries given in the NA. Further, we multiply the average rate of return to capital from the non-natural resource sectors with the capital employed in each natural resource sector to get return on fixed capital.

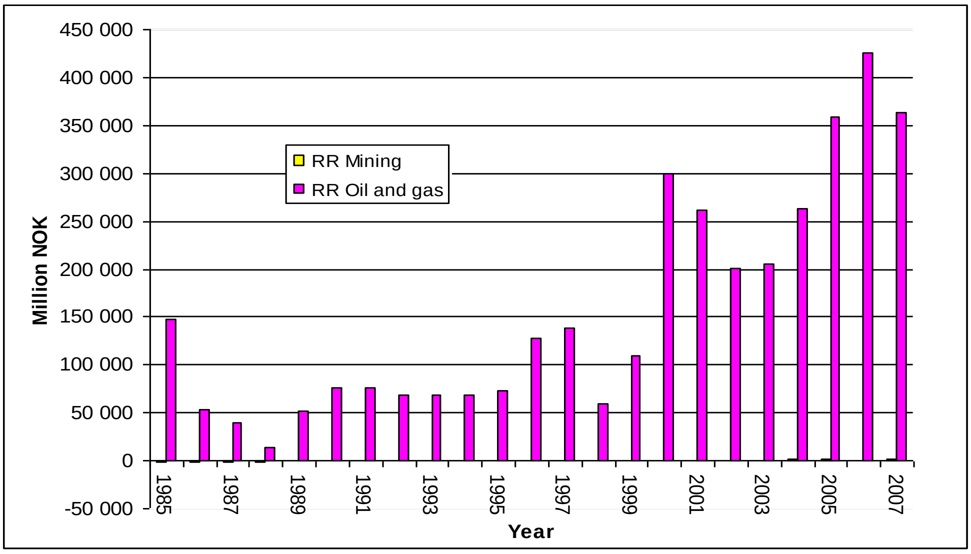
In Figure 1 and 2 we show the resource rents in Norway for the period 1985 to 2007 based on a 4 percent rate of return to capital:

Figure 1 "Renewable resources"



The resource rent in hydropower shows a positive trend in the period, and from 2002 to 2003 and from 2005 to 2006 the increases were especially large. At least two factors could be causing the increase: I) The Norwegian Electricity Market as undergone a major restructuring due to the deregulation that took place in the nineties, and II) The marginal cost of electricity from coal and gas increased in 2006 due to the European climate gas emission trading scheme. The figures used to calculate the resource rents show that both capital and labour costs tends to decrease over the period, while the basic value of production increases. Note also that the negative resource rent in agriculture is becoming less negative. This is in line with public policy.

Figure 2 "Non-renewable resources"



The resource rent in oil and gas increased considerably from the 1990'ties to the period from year 2000. The main reason is the higher oil and gas prices. Further, we see that the resource rent in mining is very small; on average for the period it was 115 million NOK. [1]

3.2 Step 2: Decomposing NNI

Net National Income (NNI) for any given year can then be decomposed in the following way:

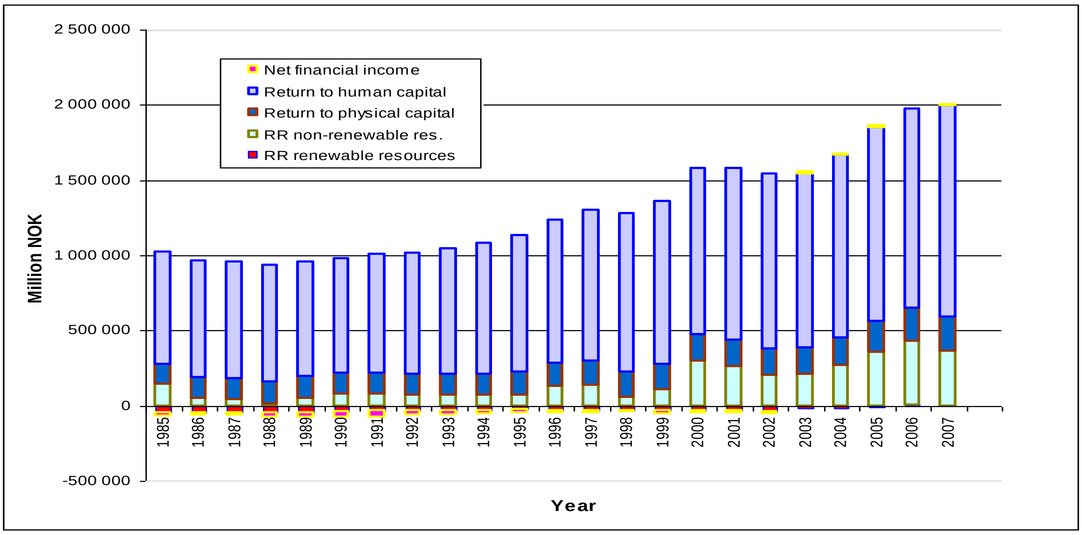
NNI =
- I) + Resource rents from renewable natural resources; fish, aquaculture, forestry, agriculture, hydropower, etc.
- II) + Resource rents from non-renewable natural resources: oil and gas, mining, etc.
- III) + Net return on fixed capital
- IV) + Net income from financial wealth
- V) + Value added tax
- VI) + Return on human capital

Resource rents are calculated as described above. The value of fixed capital is given in the national accounts. In order to calculate total return we have used the same rate of return as we used for the resource rents calculations, i.e. either 4 percent or the average rate of return to capital for all non-natural resource industries in that particular year. Net income from financial wealth is given in the national accounts. Lastly, the return on human capital is calculated residually:

Return on human capital = NNI - resource rents - net return on fixed capital - net income from financial wealth

The return on human capital should compromise all contributions from labour, that is, raw labour, the effect of education and so-called *social capital*. Clearly, since it is calculated residually, it also compromises all kinds of positive externalities between capital, technology and labour; in particular, it will pick up all the growth in NNI that cannot be explained by increased factor usage. Note also that the value added tax is included in the human capital component. There is no special reason for doing this apart from it being convenient.

Figure 3 "Decomposition of NNI"



[1] In order to make the figures comparable between years, we have deflated all figures with a year 2007 price index, which is a weighted sum of the consumption price index and the price index for public spending.

We note that the human capital component dominates, and that its contribution to NNI increases with approximately the same rate as NNI itself. We also note that the contribution from the non-renewable resource sector, mainly oil and natural gas, is highly volatile, which is due to variations in world market prices on oil and gas. As mentioned the renewable resource sectors taken together do not contribute to NNI. The reason is mainly the high subsidies in agriculture, which leads to negative resource rents in this sector, see Figure 1. (See Appendix for a formal treatment of the decomposition of NNI).

3.3 Step 3: Calculating contributions to national wealth

The point of departure for the third step is the decomposing described above. Firstly, we evaluate to what extent current income from the renewable resources is sustainable. Statistics Norway publish stock data for the most important stocks like standing forest, arctic cod etc. We check these stock data for each resource, and if the stock is constant or increasing, we assume that the income stream can be continued for all subsequent years. The value of a renewable resource in this case is:

$$(1) \qquad NV_i = \sum_{t=t_0}^{\infty} \frac{RR_{t_0}^i}{(1+\delta)^{t-t_0}} ,$$

where NV_i is the present value of the income stream from resource i, $RR_{t_0}^i$ is resource rents from resource i for the year t_0, that is, the year for which we calculate national wealth, and δ is the discount rate. The choice of discount rate for these kinds of valuations is discussed in Kunte et al. (1998). According to Kunte et al. the relevant discount rate for resource allocation decisions over time is the social rate of return on investment (SRRI). The SRRI consist of two parts; the pure rate of time preference and a multiplicative between consumption growth and the elasticity of marginal utility of consumption. The SRRI is mostly taken to be between 2 and 4 percent, and we have used 4 percent in our calculations.

Note that if $RR_{t_0}^i$ is low, for instance due to bad management of the resource, we implicitly assume that the bad management will continue. Thus, the calculation only tells us the value of the resource given the management practice of today, and not the value given that the management practice were chosen to maximize the resource rents.

For the nonrenewable natural resources we know that the extraction of the resource is bounded to stop some time in the future. We therefore base our calculations on time paths for the price, the extraction and the cost of extraction for these natural resources. The time paths for extraction are obtained from the Ministry of Oil and Energy in Norway. The price path of oil and gas are based on an in-house model of the global oil and gas markets at Statistics Norway, while the extraction costs are based on historical costs reported in the NA.

The value of a nonrenewable resource is thus given by:

$$(2) \qquad NV_j = \sum_{t=t_0}^{T} \frac{(\omega_t^j z_t^j - \overline{c_t^j} z_t^j)}{(1+\delta)^{t-t_0}} ,$$

where ω_t^j is the price of resource j in year t, z_t^j is the extraction of resource j in year t, $\overline{c_t^j}$ is the average extraction cost of resource j in year t and T is the year where the resource is depleted.

Each time we calculate national wealth we also update the calculations for earlier years in order to be able to track the development in the wealth figures (see Greaker et al. (2005). Through this process the expectations about future prices and costs are updated. For instance, if national wealth is calculated for year t_0 and year t_0 +1, then with respect to the latter calculation, we set $\omega_t^j = \omega_{t-1}^j$, $z_t^j = z_{t-1}^j$ and $\overline{c_t^j} = \overline{c_{t-1}^j}$, $\forall t \geq t_0 + 1$. Hence, changing expectations about future resource prices will not in itself affect the development in the wealth figures since they are continuously updated.

With respect to the human capital component, we have historically witnessed a steadily increasing return. If this trend is assumed to continue, we may be criticized for being too optimistic. We therefore normally make calculations of national wealth both with and without growth in the return from human capital. The value of the human capital component is given by:

$$(3) \qquad NV_{HK} = \sum_{t=t_0}^{\infty} \frac{HK_{t_0}(1+g)^{t-t_0}}{(1+\delta)^{t-t_0}}, g < \delta ,$$

where $HK_{t_0}^i$ is the contribution from the human capital component to NNI in year t_0 (i.e. the residual above), and g is the rate of growth in the return to the human capital component. As mentioned the calculations are carried out for both g = 0 and g > 0.[2]

Lastly, national wealth NW can be calculated as the sum of the different components:

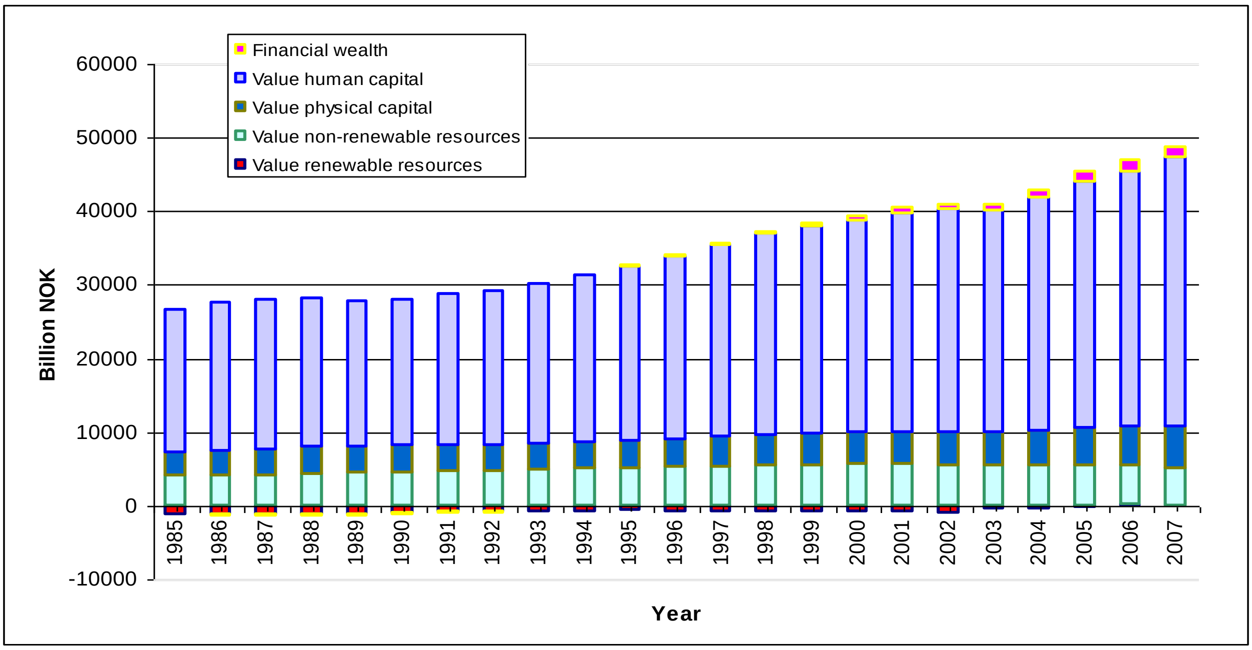
NW =

I) + present value of future resource rents from renewable natural resources
II) + present value of future resource rents from non-renewable natural resources
III) + present value of future contribution from human capital
IV) + current value of fixed capital
V) + net financial wealth

As mentioned, the values of both iv) and v) are given directly in NA. If the extraction of non-renewable natural resources is constant or declining, and if the resource rent per unit of extracted resource is constant, and if reserves are not upgraded, point ii) above will decline as time passes. Thus, in order to keep NW constant or increasing, one or more of the other components of NW have to increase. Typically, this has especially been the case for point iii) human capital. Below we present the result from the most recent calculations (with g = 0):

[2] As mentioned we apply a discount factor of 4 percent. This implies that we believe consumption to grow at a positive rate. To be consistent we should ideally then set g > 0 to allow for the positive growth rate of consumption.

Figure 4: The development in national wealth in Norway

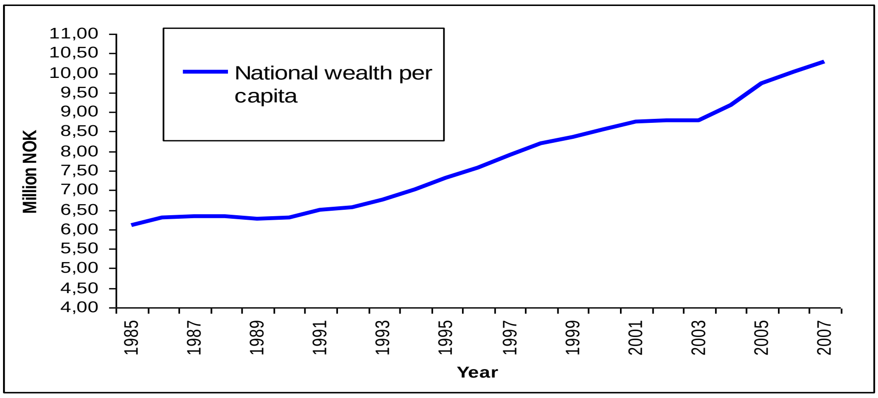


Note that the value of the non-renewable resources is declining, while the value of financial wealth is increasing. This is according to public policy as resource rents are reinvested in foreign financial assets by the Norwegian government. Although Norway has positive financial wealth, net financial income was negative in 2005 and 2006. The reason is that Norway as a whole pay higher interests on its foreign debt than it receives on its foreign assets.

From Figure 3 we also note that national wealth is increasing, and that the human capital component is the major cause behind the growth. The value of the human capital component is just a direct transformation of the "return to human capital" given in Figure 2. Thus, Figure 3 does not contain any new information about the expected future return to the human capital component apart from the assumption that the return can be kept at the same level for all future years.

Since sustainable development is linked to the well-being of persons, not the nation as a whole, we present figures for national wealth per capita in the period.

Figure 5: National wealth per capita.



As we can see directly from the figure, national wealth per capita is non-decreasing. This suggests that the development in the part of total wealth that can be measured with point of departure in the NA has been sustainable.

4. The value of the renewable natural resource sectors

As mentioned, the calculation only tells us the value of the resource given the management practice of today, and not the value given that the management practice were chosen to maximize the resource rents. This implies that the value can be negative if the bad management leads to a negative resource rent. In such cases some have argued that the value should be set to zero since one at any time has the opportunity to stop harvesting the resource. However, the current procedure is to include resources with a negative resource rent as a negative wealth component.

In the Norwegian case the renewable natural resource sectors together has zero value. This result could be misleading. It suggests that these resources are highly unimportant for Norway. However, if the government partly uses the natural resource management regime in order to reach regional policy goals, such a conclusion could be wrong. That is, instead of collecting the resource rents and redistributing them according to the regional policy goals, the management regime is made in order to fulfill some policy goals directly without redistributing resource rents. This dissipates the resource rents, and implies that if the renewable natural resource were ran down, the government would have to reallocate other resources in order to reach it goals. All other things equal, this would lower the income from the reallocated resources.

In our opinion the theoretical value of the resource given an optimal management practice should be calculated. This has been done several times for the Norwegian fisheries (see for example Flåm, Kjellemyr and Rødseth, 1996), and we propose to do the same for forestry and agriculture. This would require some methodological development as to how to treat the freed labor and capital resources.

5. Alternative ways to calculate human capital based on the NA

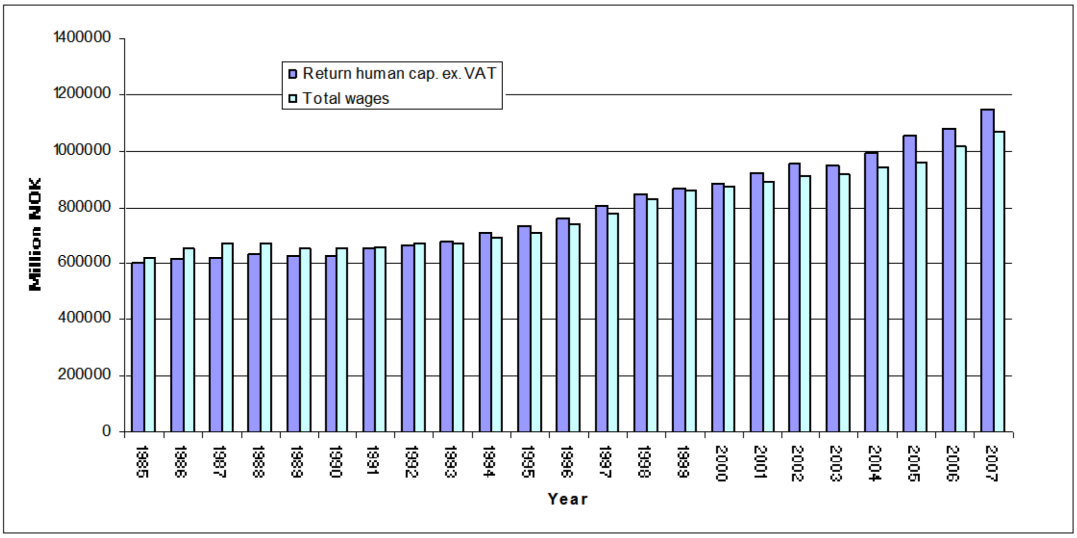
Currently, in NA there are many measures of labour effort, and among these we have; hours worked by employees, and hours worked in total by both employees and self-employed. Moreover, NA covers total wages paid to wage earners. In this section we demonstrate how this can be used to obtain an alternative measure of the human capital component that do rely on the residual approach.

From hours worked by employees in all sectors except for the of shore petroleum sector and total wages paid to wage earners in the same sectors, we obtain an average wage rate for the main land country. Assuming that self-employed could obtain this average wage in the labour market, we can calculate total value of work effort as total hours worked in Norway as a whole times the average wage calculated as just described. This figure should roughly coincide with the human capital residual.

Why do we include both hours worked by employees and hours worked by self-engaged? Firstly, some categories of self-engaged are not obliged to salary, but they do the same task as normal employees. Secondly, persons owning all shares in their firm often prefer to get their wage as dividends, and not as salary due to the tax system. This will tend to show up as fewer hours worked as employees.

When calculating the average wage, why do we not look at Norway as a whole, but only on main land Norway? Due to the high resource rents in petroleum sector, workers may have been able to negotiate a higher wage rate than in sectors of main land Norway. By just looking at the latter, we avoid this potential problem. In the figure below we compare the human capital residual exclusive the value added tax with the calculated market value of all work effort.

Figure 5: Comparing two ways of calculating human capital

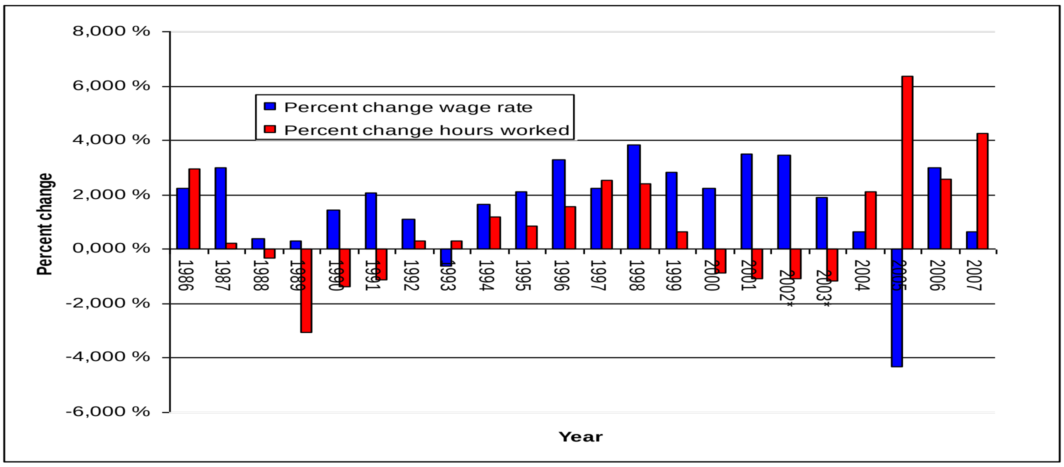


Note that the two measures follow each other closely, and in particular that they both increase sharply from 1994 and onwards. Until 1992 our wage based measure is higher than the residual ex. VAT. From 1992 on it is vice-versa. All the same, we will still have an unexplained residual i.e. that is:

Unexplained residual = NNI - resource rents - net return on fixed capital - net income from financial wealth - VAT - wages*total hours worked

Until 1992 the residual is negative, and then becomes positive for the rest of the period. It is not clear to us how this residual should be explained. It varies between 2 and 5% of NNI so it is not totally irrelevant. In addition, we have not explained why the human capital component increases in value. Of course we can decompose, the changes in the yearly wage payments into a quantity and a price effect.

Figure 6: Changes in wage rates and number of hours worked



Note that the human capital component declined in 1989 and in 1993. Further that, the first decline was caused by a major decline in number of hours worked, and that a minor drop in the real wage rate caused the second decline. Note also the large increase in number of hours worked from year 2004 and onwards.

The total number of hours worked and the wage rate in a particular year do not however tell us much about how income from the human capital component is expected to develop in the future. In order to get better predictions of future income, we suggest decomposing current income from the human capital component even further. One first attempt in this direction is to leave the assumption that the rate of return on human capital can be kept forever (e.g. see equation (3)), and to look at the expected average remaining work years of the current labor force.

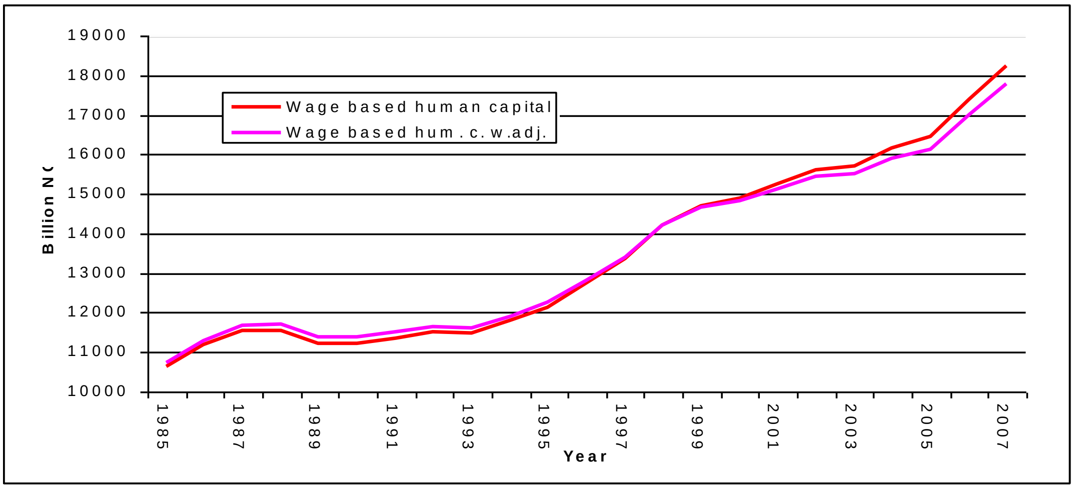
Thus the value of the human capital in a given year is given by:

$$(4) \qquad NV_{HK} = \sum_{t=t_0}^{RW_{t_0}} \frac{\overline{HK}_{t_0}(1+g)^{t-t_0}}{(1+\delta)^{t-t_0}}, g < \delta ,$$

where RW_{t_0} is expected average remaining work years of the current labor force, $\overline{HK}_{t_0}$ is the contribution from the human capital component to NNI in year t_0, calculated as described above directly from wages, and g is the rate of growth in the return to the human capital component.

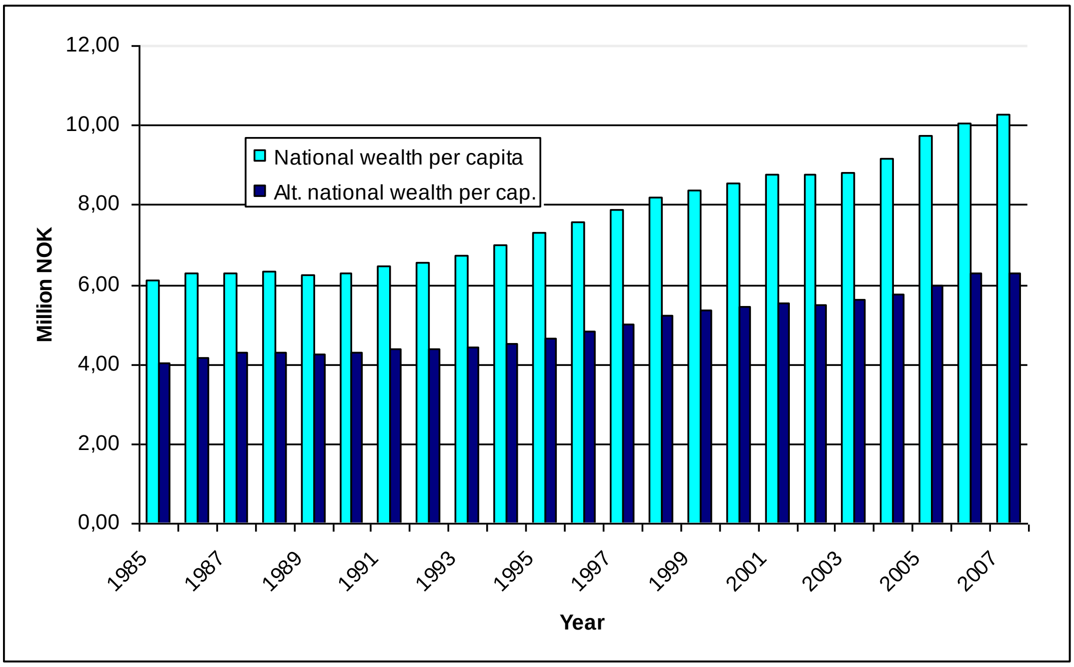
In Norway RW_{t_0} has experienced a slight decline in the period 1986 to 2007. However, the decline is very small so that the effect of a shorter remaining return from the current human capital stock is small as well.

Figure 7 "Age adjusted human capital"



In Figure 7 we have calculated the human capital component based on the wage rates and the total number of hours worked. In addition we have adjusted the light curve for the average remaining work years of the current work force in each year. In order to compare, the dark curve just assumes a fixed number of years remaining in the work force, which is equal to the average for the period as a whole. In the beginning of the period the average age of the workforce was declining, while at the end of the period, it increased. The effects of this are easily seen from the diagram. However, we have not taken into account that the number of hours worked per year may also depend on both the total number of people in the workforce and the age composition of the workforce. In order to include such effects we would need a more detailed decomposition of the workforce.

Figure 8 Adjusted national wealth per capita



Note that when we adjust the human capital calculation for the expected average remaining years in the work force, the growth in national wealth per capita is not as high. National wealth per capita is also lower since we do not any longer assume that the rate of return on human capital can be kept forever, but only as long as the expected average remaining work years of the current labor force.

6. Alternative ways to calculate the human capital component

Our preliminary analysis of human capital based solely on data given in the NA suggests looking more deeply into the issue how to calculate the human capital component.

Human capital has been given many definitions, and a good account of some of those is given in Stroombergen, Rose and Nana (2002). One example is the definition of OECD (2001): *Human capital is the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being.* This definition points to the crucial fact that human capital is embodied in humans that all are *free* women and men. Human capital is therefore not, unlike physical capital, traded in markets.

So far we have been treating human capital together with labour as one entity. In the literature our human capital component is decomposed into *raw labour*, *education/skills* and *social capital*. Moreover, in the same literature the notion human capital is mostly only connected to *education and skills*. Furthermore, the value of the human capital component has been calculated for at least three different purposes other than evaluating sustainable development (see e.g. Stroombergen, Rose and Nana, 2002):

- To evaluate education policy
- To evaluate what determines employment

- To understand economic growth

We will not venture into the results of this literature here, but only look briefly at the methods used for calculating the human capital component in parts of this literature.

Many methods for estimating human capital have been developed; see Stroombergen, Rose and Nana (2002) for an excellent survey. Basically, the methods for estimating human capital can be categorized in following way:

1. The cost based method that estimates human capital from the input side
2. The revenue generating method that estimates human capital from the output side
3. The current stock characteristics method

When estimating human capital from the input side, all expenses that contribute to human capital formation are summed. The most obvious expenses are public and private direct expenses to education and foregone income while under education. But also other expenses should ideally be included, for instance expenses to on-job training and employer financed outside job courses. To avoid the human capital component becoming bigger and bigger with time, the measure should also include some kind of depreciation. People leave the workforce, they stay unemployed for longer periods of time, or they start in a new trade, all which implies a reduction of the human capital component.

When estimating human capital from the output side, it is the expected wage obtained in the future labour market that matters. This method is much used in the growth literature, and we elaborate on this method further in Section 6.2. Two points are worth mentioning here: Firstly, the method doesn't separate well between social capital and human capital. To the extent that the level of social capital is high in a country, it would presumably increase the wage obtained in the labour market in general. Secondly, it does not measure the benefits from human capital that is not paid for in markets. Clearly, a higher education can yield benefits that are intangible, and therefore, resistant to measurement.

Finally, one could also construct a proxy measure for the current state of the human capital component. Such a measure would among others include average years of schooling in the population, the extent of literacy, unemployment rates and the health status of the population. Clearly, it is difficult to translate such a characterization of the stock of human capital into a money measure. This implies that the measure does not fit equally well with the rest of the national wealth approach as outlined above.

In an ideal world the three measures should yield the same result. That is, total investments in human capital should equal the discounted sum of expected returns, which again should equal the estimated value based on current characteristics. Clearly, there are many reasons why this is not the case, of which one is that many benefits from education are not valued in markets. The strand of literature in which sustainable development has been the point of departure has seemingly mostly used the input-based approach, while as mentioned; the economic growth literature has used the output-based approach (sometimes combined with the input-based approach).

6.1 Approaches followed in the sustainable development literature

As already mentioned, most of the literature on indicators for sustainable development choose to focus on the genuine savings indicator. It is easier to give the genuine saving indicator a formal backing (see e.g. Asheim, 2004 and the discussion above). The genuine savings indicator has undergone some development since first applied by Pearce and Atkinson (1993). In the book "Where is the wealth of nations?" (World Bank, 2005), Hamilton et al. calculate the genuine savings indicator in the following way:

Genuine savings =

I) + Net investments in physical capital

II) + Expenses for education e.g. wages paid to teachers, but excluding investment in buildings etc.

III) - Rents in the non-renewable natural resource sectors

IV) - Damages to the environment from particulate matter and carbon dioxide

The genuine savings indicator equals changes in the human capital component with expenses to education in a particular year. Hence, it does not include any form of depreciation. Moreover, foregone earnings are also excluded. Lastly, it is difficult to include aspects of human health. Clearly, expenses to health cannot be used, as they can as well be signs of bad health and not good health. Thus, it seems like the input based approach as used by the literature on sustainability should be complimented by a stock characterization approach. This is to some extent what is done in another chapter of the above-mentioned book.

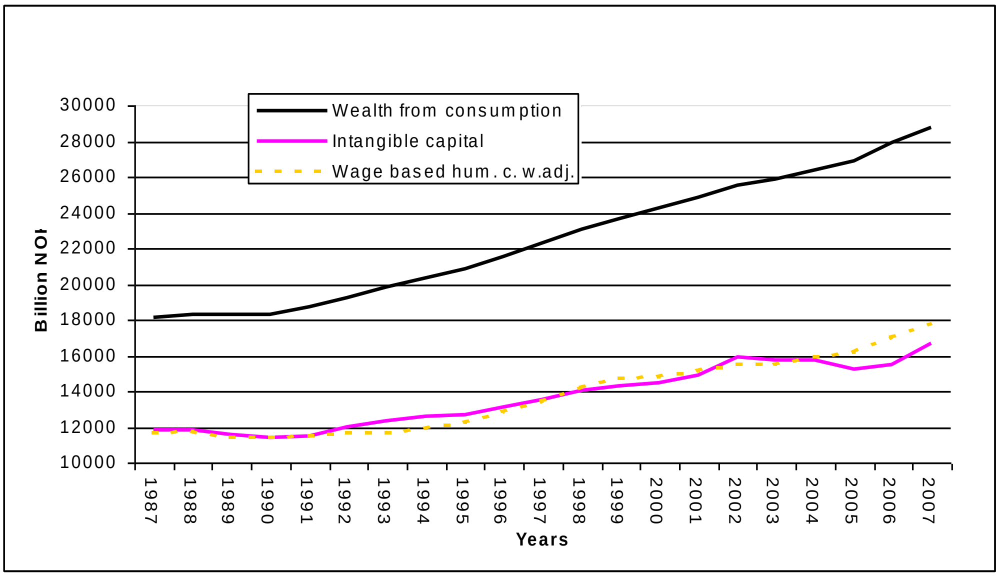
As Hamilton et al. note, the measure of changes in human capital is crude, and in another chapter of "Where is the wealth of nations", Hamilton et al. investigate to what extent different factors related to education, skills and social capital could explain the human capital component. Their point of departure is the following definition of national wealth:

(5) $$NF = \sum_{t=t_0}^{t=25} \frac{\overline{C}}{(1+\rho)^{t-t_0}},$$

where NF is national wealth, $\overline{C}$ is average consumption over the last three years and ρ is the pure rate of time preference, which is set equal to 1,5 percent. Furthermore, a time horizon of 25 years is chosen since it is often used as the time span of one generation. It is also a crude estimate on the average years left in the labour force for the current workforce.

Having calculated wealth in this manner for a cross section of countries, the authors decompose wealth in each country by the same approach as described in the former section. That is, they calculate the value of the natural resources, physical capital and financial holdings and subtract that from their wealth measure. The residual is denoted *intangible capital*, which among others by the definition of national wealth must comprise human capital and social capital. If we do the same for Norway, but use our already calculated measure for average remaining work years, we get the following figure:

Figure 9 The intangible capital residual



Note how well the "intangible capital residual" coincides with our calculation of human capital based on formula (4). Wealth based on consumption from formula (5) will also coincide with wealth based on the alternative calculation of human capital from formula (4). Clearly, to large extent this is a coincidence based on the chosen discount factors: 1,5% for consumption and 4% for all capital earnings.

In their next step Hamilton et al. run a regression aiming to explain the intangible capital residual by three variables: average length of education per worker, remittances from abroad and a rule of law index among others based on political stability and absence of violence. They then find that the three variables explain 89 percent of the variation in the intangible capital residual.

6.2 Approaches in the growth literature

While the sustainability literature mostly has tracked changes in the value of human capital from the input side, that is, wages to teachers etc., the growth literature has also measured human capital from the output side. Becker (1975) calculates rates of return to education by looking at wage differentials between workers with different levels of education. Jorgenson and Fraumeni take Becker's approach a step further, and in a series of contributions they both calculate the human capital component of the US and explain their method (see Jorgenson and Fraumeni 1989 and 1992). On the other hand, as far as we know, the approach followed by Jorgenson and Fraumeni has not been applied by the literature on indicators for sustainable development. Very broadly their approach follows the following steps:

1. Construct a database containing the economic value of labour market activities for various categories of people. At least the database should include wage rates and labour market participation cross-classified with sex, education attainment and age. The database should ideally comprise all persons aged 16 to 75.
2. Program an algorithm calculating the lifetime income for each person in the database. That is, we assume that each person in the future will obtain the same wage rate and have the same labour market participation rates as elder persons with the same characteristics currently living. The sum of the lifetime incomes will be equal to the total human capital stock.
3. Update the database periodically, ideally each year; such that all changes in human capital due to changes in education attainment, labour market participation, demographic development etc. can be traced.

Note that, Jorgenson and Fraumeni also included the value of leisure (using the after tax marginal wage rate of the person in question). The method of Jorgenson and Fraumeni has been applied to other countries than the US, se for instance an application to Australia by Hui Wei (2004) and to Norway by Ervik, Holmøy and Hægeland (2003).

In the following we illustrate the three steps with a simple example. We concentrate on the current labour force, and leave out students. Let the labour force be dived by age and education attainment:

Table 1 "Decomposing the labour force"

	Young; u	Old; g
Primary schooling; s	$w_{t_0}^{us}, l_{t_0}^{us}, n_{t_0}^{us}$	$w_{t_0}^{gs}, l_{t_0}^{gs}, n_{t_0}^{gs}$
High school; v	$w_{t_0}^{uv}, l_{t_0}^{uv}, n_{t_0}^{uv}$	$w_{t_0}^{gv}, l_{t_0}^{gv}, n_{t_0}^{gv}$
College; h	$w_{t_0}^{uh}, l_{t_0}^{uh}, n_{t_0}^{uh}$	$w_{t_0}^{gh}, l_{t_0}^{gh}, n_{t_0}^{gh}$

where $w_{t_0}^{ij}, l_{t_0}^{ij}, n_{t_0}^{ij}, i = u, g, j = s, v, h$, is *average wage rate* for workers of age i and with education j at t_0, *number of hours worked* for age group i with education level j at time t_0, and *the size of the population* for age group i with education level j at time t_0.

The value of the human capital component in year t0 is then equal to:

$$(5)\qquad HK_{t_0} = \sum_j w_{t_0}^{uj} l_{t_0}^{uj} + \sum_j w_{t_0}^{gj} l_{t_0}^{gj} + \theta \sum_j w_{t_0}^{gj} n_{t_0}^{uj} (l_{t_0}^{gj} / n_{t_0}^{gj})$$

where θ is the discount factor. The discount factor should include the probability of being alive. In the first period, the calculation is straight forward, and the income stream from the human capital component is equal to the sum of wage rate times hours worked for each combination in Table 1. This figure should coincide with average wage times total number of hours worked for the country as a whole.

In period two the old are retired and no longer participating in the labour force. Moreover, the young has been given the wage rate of the old with the same level of skills, and the labour participation of the formerly young is set equal to the labour participation of the old in the first period i.e. $(l_{t_0}^{gj} / n_{t_0}^{gj})$. Hence, we assume that the wage rates for equal combinations of skills/age are constant. On the other hand, the method picks up effects from higher average levels of education among the young. The method also takes into account demographic changes and labour market participation.

Including a student population $n_{t_0}^{c}$ and additional time period, would give the following changes to equation (5):

$$HK_{t_0} = \sum_j w_{t_0}^{uj} l_{t_0}^{uj} + \sum_j w_{t_0}^{gj} l_{t_0}^{gj} + \theta \sum_j w_{t_0}^{gj} n_{t_0}^{uj} (l_{t_0}^{gj} / n_{t_0}^{gj}) + \theta \sum_j \phi_j w_{t_0}^{uj} n_{t_0}^{c} (l_{t_0}^{uj} / n_{t_0}^{uj}) + \theta^2 \sum_j \phi_j w_{t_0}^{gj} n_{t_0}^{c} (l_{t_0}^{gj} / n_{t_0}^{gj})$$

where ϕ_j is the probability that a student in year t0 obtains education of type j. The two last terms above are the expected incomes from the student population. In the simple example we assume that all people go through three stages; student, young workers and old workers. Hence, in the last period, only the students work. The probabilities ϕ_j will have to be estimated separately.

Applied continuously every year, or for instance, every fifth year, the method of Jorgenson and Fraumeni can uncover underlying structural changes that may lead to a future decline in NNI. Examples are:

- Demographic changes: If cohorts entering the labor market are smaller than cohorts leaving, human capital measured by the Jorgenson and Fraumeni approach will *ceteris paribus* decline.
- Changes in educational attainment: If cohorts entering the labor market have chosen types of education with on average lower market value than cohorts leaving, human capital measured by the Jorgenson and Fraumeni approach will *ceteris paribus* decline.

None of these effects will necessarily show up in NNI figures, and hence, not be uncovered by the national wealth approach currently used by Statistics Norway.

On the other hand, to the extent that wages are explained by other factors than what is measured, the method can yield biased estimates of human capital. Examples of such factors are; terms of trade effects, future wage increases due to better on-the-job training etc. We would also expect health to affect wage earnings, however, it seems difficult to add health status to the Jorgenson-Fraumeni method, especially since future health status is likely a lot harder to predict than future labour market participation and wage earnings. Moreover, as mentioned, the method does not distinguish between human and social capital. To the extent that improved social capital has lead to higher wages in the past, this will be attributed to human capital.

That said, in our opinion, the output-based approach is the method that has the best fit to the NA based national wealth calculations. The NA based national wealth calculations only deal with the parts of the capital stocks that can be given an economic value from market prices. As can be seen from Figure 4, wage earnings explain the human capital residual very well. However, by employing the output based approach, we will hopefully get a far better grip on what is driving changes in the average wages. Further, it will help us predict future changes in wages, which of course is crucial for the value of the human capital component.

7. Discussions and Conclusion.

We have focused on the inter-generational aspect of sustainable development. In our opinion this is the proper focus when discussing sustainable development. The intra-generational aspect is covered in many other policy areas. Moreover, if society happens to follow a non-sustainable inter-generational development path, intra-generational aspects seem to us of secondary importance. As long as sustainable inter-generational development paths are obtainable, society must firstly assure that one of the sustainable development paths is chosen, which is exactly the purpose of the national wealth indicator.

Of course, there may be many obtainable sustainable development paths of which some may be preferable to society of reasons pertaining to intra-generational justice. However, in our view, the two issues should ideally be disconnected: First, we should choose a sustainable path that maximizes inter-generational income, second, we should discuss how to redistribute income.

This paper has had two purposes; a) It describes and presents the current method used at Statistics Norway for calculating national wealth and b) It proposes ways in which the method could be improved with special emphasis on the calculation of the human capital component. The major choices seem to be between the input based and the output based approach, and whether the economic valuation should be complimented by a stock characterization approach in which no attempts are made to put an economic value on the characterization.

When calculating the other components of national wealth, both output- and input based methods are used. For instance, regarding physical capital, the NA use an input based method i.e. the perpetual inventory approach, and we use the NA figure directly. On the other hand, when calculating the value of the natural resources we use an output based approach, that is, the value of a resource is the discounted stream of net income from harvesting the resource. Thus, there is nothing in the current method that tells us to choose an output based approach before an input based approach, or *vice-versa*.

One of the strengths of the genuine savings indicator, according to some of its proponents, is that it does not depend on predictions of future prices. That is, changes in natural resource wealth, in physical capital and in human capital are all measured by current prices only. Tracking changes in the human capital component by the output-based approach implies that one makes predictions about future prices. That is, the valuation is based on the assumption that younger people will in the future receive the same wages as the currently living older people with the same characteristics. Thus, with respect to the genuine savings indicator, basing the calculation of changes in the human capital component on the output-based approach would imply a break up with an important principle.

The genuine savings indicator is based on Hartwick's rule. Many researchers has questioned the appropriateness of Hartwick's rule for open economies, see e.g. Sefton and Weale (1996). This suggests continuing to track the development in national wealth. National wealth calculations are all based on predictions about the future. Further, there clearly exist methods that could improve the measurement of human capital component of national wealth. Of these methods the output-based approach seems to be the best fitted for national wealth calculations as it explicitly values the human capital component through the market prices obtained from its services. The method will require new databases to be constructed. We however propose that such databases are established, and that more experience is gathered with valuation of human capital based on lifetime incomes of the current workforce population.

The input based approach also put a value to the human capital component. However, it is harder to fit the method with NA based national wealth calculations. Moreover, measuring expenditures on education does not say anything about the quality of the education, and hence, it is maybe not a good measure of the value of the education. The human capital market is fundamentally different from the physical capital market. With respect to the physical capital market, it makes sense to assume that the price of a piece of capital equipment is equal to the future income stream the owner expects to receive from the piece of capital equipment. Hence, in this case the output-based and the input-based approach are equivalent. Such equivalence is harder to defend with regards to human capital. Firstly, the human capital owner only pays a part of the human capital formation. Secondly, human capital formation is generally perceived to yield benefits to the owners, which are not measured in markets. Thus, only by coincidence, would the output-based and the input-based approach yield equivalent results in the human capital case.

There is also ways to improve the input based valuation of human capital. For instance, one can treat forgone income by students as an investment, and leaves from the labour force as disinvestments e.g. due to retirement. Again we would need to construct a database tracking the number of students, time spent for study etc. All the same, this seems worth evaluating when applying the genuine savings indicator.

Finally, independent of which method is chosen, one should consider supplementing both the output and input based approach with the characterization approach. As noted by OECD (2001) the aim of human capital formation is to facilitate human well-being. Most consider health to be a central part of human well-being, however, health aspects are hard to incorporate in the two other approaches.

References

Alfsen Knut and Mads Greaker (2007), From natural resources and environmental accounting to construction of indicators for sustainable development, forthcoming in *Ecological Economics*.

Asheim Geir (2004), Indicators of welfare improvement and sustainability, In NOU: "Simple signals in a complex world", Ministry of Finance, Oslo.

Aslaksen I., K. A. Brekke, T. A. Johnsen and A. Aaheim (1990), Petroleum Resources and the Managment of National Wealth, fra Recent Modelling Approaches in Applied Energy Economics, av O. Bjerkholt, Ø. Olsen and J. Vislie, Chapman and Hall Ltd.

Barro R. J. and X. Sala-i-Martin (2000), Economic Growth, MIT Press.

Becker Gary S. (1975), Human Capital - A theoretical and empirical analysis with special reference to education, 2'nd edition, NBER, New York.

Brekke Kjell Arne (1997), Hicksian Income from Resource Extraction in an Open Economy, *Land Economics* 73, p.516-527.

Brekke Kjell Arne., Øyvind Lone and Tor Rødseth (1997), Økonomi og Økologi (Economy and Ecology), ad Notam Forlag.

Dasgupta Partha and Geoffrey M. Heal (1979), Economic Theory and Exhaustible Resources, Cambridge University Press, Cambridge.

Ervik A. O., E. Holmøy and T. Hægeland (2003), A Theory-Based Measure of the Output of the Education Sector, Discussion Paper No. 353, Statistics Norway.
Flåm Sjur, Torun Kjelby and Tor Rødseth (1996) in Brekke et al., Økonomi og Økologi (Economy and Ecology), ad Notam Forlag.
Greaker, Mads, Pål Løkkevik and Mari Aasgaard Walle (2005): Utviklingen i den norske nasjonalformuen fra 1985 til 2004. Et eksempel på bærekraftig utvikling? (Development of the Norwegian national wealth 1985-2004. An example of sustainable development?) Report 2005/13, Statistics Norway, Oslo. ISBN 82-537-6789-7.
Hanley Nick, Ian Moffat, Robin Faichey and Mike Wilson (1999), Measuring Sustainability: A Time Series of Alternative Indicators for Scotland, *Ecological Economics* 28, p. 55-74.
Harris J.M. (2002), Environmental and Resource Economics - A Contemporary Approach, Houghton Mifflin Company, Boston.
Hartwick John (1977), Intergenerational Equity and the Investing of Rents from Exhaustible Resources, *American Economic Review* 67 (5), p. 972-974.
Jorgenson Dale W. and Barbara M. Fraumeni (1987), The Accumulation of Human and Non-Human Capital, 1948-1984, in The Measurement of Saving, Investment, and Wealth edited by R. R. Lipsey and H. S. Tice, NBER Studies in Income and Wealth, Volume 52.
Jorgenson Dale W. and Barbara M. Fraumeni (1992), Investment in Education and U.S. Economic Growth, *Scandinavian Journal of Economics* 94, p.51-70.
Kunte A., K. Hamilton, J. Dixon and M. Clemens (1998), Estimating National Wealth: Methodology and Results, Environmental Economic Series, Paper No. 57, The World Bank.
Lindholt L. (2000), On natural resource rent and the wealth of a nation, Discussion Paper No. 281, Statistics Norway.
Meadows, Dennis L.; Meadows, Donella H.; Randers, Jørgen og Behrens, William W. III (1972), The Limits to Growth: a report for the Club of Rome's project on the predicament of mankind, Earth Island, London.
Moe T. (2007), The Norwegian Model of Sustainable Development. A Policy Oriented Capital Framework for Measurement and Policies, paper presented for the WGSSD, Geneva April 2007.
NOU (2005), Enkle signaler i en kompleks verden - Indikatorer for bærekraftig utvikling (Simple signals in a complex world - Indicators for Sustainable Development), Ministry of Finance, Oslo.
OECD (2003), Sources of Economic Growth in OECD Countries, OECD Publishing
OECD (2001), The Well-being of Nations - The Role of Human and Social Capital, OECD Publishing
Pearce David W. and Giles D. Atkinson (1993), Capital theory and the measurement of sustainable development: An indicator of "weak" sustainability, *Ecological Economics* 8, p.103-108.
Sefton J. A. og M. R. Weale (1996), The net national product and exhaustible resources: The effects of foreign trade, Journal of Public Economics 61, p. 21 - 47.
Smith T. (2006), Human and social capital in a sustainable development context, paper pepared for the WGSSD, Paris, September, 2006.
Solow Robert M. (1993), An Almost Practical Step toward Sustainability, *Resources Policy 19*, p.162-172.
Solow Robert M. (1986), On the Intergenerational Allocation of Natural Resources", *Scandinavian Journal of Economics* 88, p.141-149.
Stroombergen A., D. Rose and G. Nana (2002), Review of the Statistical Measurement of Human Capital, Statistics New Zealand
Svensson Lars E. O. (1986), Comment on R.M. Solow, "On the Intergenerational Allocation of Natural Resources", *Scandinavian Journal of Economics* 88, p. 153-155.
Wei Hui (2004), Measuring the Stock of Human Capital for Australia, Working Paper No. 2004/1, Australian Bureau of Statistics.
World Bank (2005), Where is the Wealth of Nations? World Bank, Washington, D.C.

Appendix

Our method of calculating national wealth can also be illustrated with the following simple example. Let the economy consist of three sectors; one traditional sector X, one renewable resource sector Y and one non-renewable resource sector Z. Let; x, y, z denote gross income in the three sectors, and let all product specific taxes and subsidies be added/subtracted from the gross incomes. Let further vi be use of intermediates for each sector i, i = x, y, z. In the same way, let Ai , Ki , Di , denote use of labour, capital stock and consumption of capital, respectively. Finally, let rt denote the rate of return to capital in year t, and I the net income from financial wealth. We assume that a value added tax; t, is only levied on the traditional sector X.

Net national income (NNI) for any year t can then be defined as follows:

(1) NNI = ((1+t)x - vx) + (y - vy) + (z - vz) - Dx - Dy - Dz + I

Let wi denote the average wage rate in sector i, and hi the number of hours worked in sector i. (That is, we have Ai= wi hi).

We then decompose NNI for any year t in the following way:

(2) NNI = (y - vy - rKy - wx hy - Dy) + (z - vz - rKz - wx hz - Dz) + wx (hx +hy + hz)
+ r(Kx + Ky + Kz) + I +tx,

where the two first terms; (y - vy - rKy - wx hy - Dy) and (z - vz - rKz - wx hz - Dz), are the resource rents in sector Y and Z. The two next terms are the contribution from labour and the return on capital, respectively. Note that we set wx (hx +hy + hz) equal to the return on human capital, and not (Ax + Ay + Az) since wage rates in the natural resource sectors may be higher than in the traditional sector due to wage bargaining over the resource rents.

For any year t, the rate of return on capital is calculated:

(3) $$r = \frac{x - v_x - A_x - D_x}{K_x}$$,

that is, as operating surplus in sector X divided by the capital stock in sector X. One may ask whether the decomposition in (2) is correct? Equation (2) can be simplified:

(2)' NNI = (y - vy) + (z - vz) - Dy - Dz + Ax + rKx + I + tx

By comparing (1) and (2)', we note that the decomposing is only correct as long as:
Ax + rKx = (x - vx) - Dx. On the other hand, from (3), we observe that this is true by our method of calculating the rate of return to capital.

The contribution from human capital is then calculated residually in the following way:

(2)" Atot = NNI - (y - vy - rKy - Ay - Dy) - (z - vz - rKz - Az - Dz) - r(Kx + Ky + Kz) - I,

where Atot = wx (hx +hy + hz) + tx. That is, value added tax is included in the human capital component. Further, NW in any given year t can then be written:

$$NW = \sum_{t=0}^{\infty} \frac{(y - v_y - r_t K_y - w_x h_y - D_y)}{(1+\delta)^t} + \sum_{t=0}^{T} \frac{(z_t - v_{tz} - r_t K_{tz} - w_x h_{tz} - D_{tz})}{(1+\delta)^t} + \sum_{t=0}^{\infty} \frac{A_{tot}}{(1+\delta)^t} + K_{tot} + F$$

where δ is the discount rate, T is the anticipated time when there are no more reserves of the non-renewable resource left, Ktot (= Kx + Ky + Kz) is the capital stock as given from NA in the year t, and F is the net financial wealth as taken directly from NA in the year t. Note that it is assumed that the resource rent from the renewable resource in year t can be continued forever. The same assumption is also made for human capital.

In the calculation at Statistics Norway we have often used a discount factor that is smaller than the rate of return i.e. δ < r. The difference can be interpreted as a risk premium. When the rate of return is calculated from (3), we do not properly include the risk of bankruptcy. In case of bankruptcy, all equity will be lost, however, such losses are not included in the operating surpluses from the national accounts (NA). With respect to δ , we use *the social rate of return on investment* (World bank 1998).

In our calculation we have not included future, expected economic growth, although it is no problem. Usually it is done by assuming that the return on human capital will grow with a rate g. This yields the following expression for national wealth:

$$NW = \sum_{t=0}^{\infty} \frac{(y - v_y - r_t K_y - w_x h_y - D_y)}{(1+\delta)^t} + \sum_{t=0}^{T} \frac{(z_t - v_{tz} - r_t K_{tz} - w_x h_{tz} - D_{tz})}{(1+\delta)^t} + \sum_{t=0}^{\infty} \frac{(1+g)^t A_{tot}}{(1+\delta)^t} + K_{tot} + F.$$

In order for national wealth to converge to a finite number we must have g < δ . As mentioned we have set g = 0 in our calculations.