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Abstract:
This paper presents a satellite account in which investment in human capital is considered as a produced product/asset. It is not the education sector but the individual person taking education or training/courses that is the genuine producer of human capital. The former only provides education services that are used as one of the production inputs for the latter. Since another fundamental input is own labor services, human capital produced and embodied in the individual is regarded as being owned by the person in concern. It is demonstrated that the gross operating surplus generated from the production of human capital equals the differences between the estimates by the cost-based and the income-based approaches, which constitutes the first step towards making reconciliation between the estimates within one and the same framework. Finally, a numerical example based on supply and use tables shows the feasibility of implementing such a satellite account in practice.

Keywords: human capital, satellite account, output of education sector, supply and use tables

JEL classification: C82, E01, H52, I20, J24

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Sammendrag

Denne paper-en presenterer en satellitt konto der investering i humankapital er regnet som et produsert produkt / eiendel. Det er ikke utdanningssektoren, men den enkelte person å ta utdanning eller opplæring / kurs som er ekte produsent av humankapital. Den førstnevnte bare gir utdanningstjenester som er brukt som en av produksjons innsats for den sistnevnte. Siden en annen grunnleggende innsats er egne arbeidskrevende tjenester, humankapital produsert og nedfelt i den enkelte regnes som blir eid av personene seg selv. Det er demonstrert at brutto driftsresultat generert fra produksjonen av humankapital tilsvarer forskjellene mellom beregninger gjort av kostnads-basert og resultat-baserte tilnærminger, som utgjør det første skrittet mot å gjøre forsoning mellom estimatene innenfor ett og samme rammeverket. Til slutt, et numerisk eksempel basert på tilgang-og-anvendelses tabeller viser muligheten for å gjennomføre en slik satellitt-konto i praksis.

1. Introduction

Human capital is broadly defined as 'the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being' (OECD, 2001). Due to its high importance in many respects, a systematic and standard measure of the human capital can serve a number of purposes.[1]

However, human capital as an individual asset has not yet been incorporated into the System of National Accounts (SNA) that is an international standard for compiling accounts suitable for measuring, monitoring, and analyzing the economy and its constituents. There are basically two main arguments against its inclusion. One is attributed to the 'production boundary' and the other to the 'asset boundary', as stipulated by the SNA (e.g. United Nations *et al.*, 2009).

First, human capital is usually acquired by learning, studying, and practicing. These activities cannot be undertaken by anyone else on behalf of the person considered, and thus do not satisfy the 'third party criterion' that delineates the production boundary of the SNA. Therefore, the acquisition of knowledge and skills is not considered as a process of production, even if the provision of the services by educational institutions (schools, colleges, universities, etc.) is.

Second, human capital cannot be detached from the person in whom it is embodied, nor can it be transacted separately and in its own right in the market like conventionally produced capital such as machine and equipment. Simply because it is practically difficult, if not impossible, to envisage a tradable 'ownership right' in connection with people, human capital is not treated by the SNA as an asset.

There have been repeated requests and continuous efforts with the view to bring the concept of human capital, including its formation and utilization, into the framework of national accounting (e.g. Kendrick, 1976; Jorgenson and Fraumeni, 1989; Wei, 2007; Liu, 2014). A recent review in this field has summarized the knowledge gained and issues remained in terms of human capital measurement, based on country experiences and international initiatives (see Liu and Fraumeni, 2014).

[1] For instance, measures of human capital can be used, e.g. to better understand the driving forces behind the economic growth, to assess the long-term sustainability of a country's development path, to measure the output and productivity performance of the education sector, and to inform the debate on quality of life and social progress.

Among the key challenges ahead, one is how to reconcile the large discrepancies that are found between the estimates of human capital by applying the cost-based and the income-based approaches. For instance, if the output of education sector is regarded as investment in human capital, the cost-based approach measures it as the sum of total inputs devoted to education (e.g. Kendrick, 1976), while the income-based approach measures it as increments to lifetime incomes of individuals taking education (e.g. Jorgenson and Fraumeni, 1992a, 1992b). Very often, the estimates by the former are significantly lower than those by the latter (e.g. Ervik *et al*., 2003; Gu and Wong, 2010, 2014).

Both the cost-based and the income-based approaches have certain strengths and weaknesses, and there is no easy way to discriminate one against the other to be incorporated into the SNA in the future. Nonetheless, given the large differences between the estimates derived from these two approaches, including both within one and the same framework in a consistent way is still challenging.

This paper attempts to make reconciliation between the estimates of human capital by the cost-based and the income-based approaches that are integrated within a framework of satellite account for human capital, in which both the conventional production and asset boundaries are expanded. In addition, based on a new supply and use table structure for human capital accounting, the paper also demonstrates the feasibility of the implementation of the suggested satellite account.

The rest of the paper is organized as follows. Section 2 provides an overview of how the output of education sector is measured by the SNA, the cost-based approach and the income-based approach, respectively. In Section 3, a framework of a new satellite account for human capital is presented, with its main advantages being highlighted. To facilitate understanding, Section 4 gives a numerical example within a hypothetical economy by using fictitious numbers. Concluding remarks are given in Section 5, in which possible ways for covering more interesting issues in the new framework are briefly discussed as well.

2. The output of education sector

Within the current framework of the SNA, the output of education sector is considered to be various education services provided by the sector (e.g. United Nations *et al.*, 2009). Let us start with a

conventional production account for an education sector providing one specific education service (e.g. primary education service):[2]

$$P_E E = P_M M + P_L L + CFC + NOS \quad (1)$$

$$P_M M = \sum_{i=1}^{I} P_i M_i$$

$$P_L L = \sum_{j=1}^{J} P_j L_j$$

where

P_E: Price of education service;

E: Volume of the corresponding education service;

P_i: Price of product i used by the education sector as intermediate consumption (e.g. electricity expenses);

M_i: Volume of the corresponding product i;

$P_M M$: Value of total intermediate consumption by the education sector;

P_j: Price of labor service for labor type j (e.g. wages and salaries for teacher with certain level of education);

L_j: Volume of the corresponding labor service for labor type j (e.g. actual working hours);

$P_L L$: Value of total labor input in the education sector;

CFC: Consumption of fixed capital (e.g. due to the use of school buildings) in the education sector;

NOS: Net operating surplus for the education sector.

The accounting identity as shown in equation (1) indicates that the total value of the gross output of this specific education sector ($P_E E$), after subtracting the value of intermediate consumption ($P_M M$), gives rise to the value added for the education sector that consists of compensation of employees ($P_L L$) and remuneration for capital services, the latter including consumption of fixed capital (CFC) and the net operating surplus (NOS).

It seems that accounting for education services is no different from accounting for other goods and services in an economy. However, in many countries, education services are commonly provided by

[2] For the sake of simplicity, the presentation in this paper assumes away all taxes and subsidies, trade and transportation margins. As consequences, no other (net of subsidies) taxes on production levied appear in the accounting identity. In addition, there are no difference between the basic price and the purchaser's price, and both of them are denoted simply as 'price'.

non-market producers, such as the central/local government and/or the non-profit institutions serving households (NPISHs), at, if at all, prices that are economically insignificant, which raises the issue about how to measure the output of education sector, for which there are no market transactions.

As a long convention,[3] with the government or NPISHs being treated as producers, the output of education sector (i.e. the non-market education services) is to be measured as the total costs of production, namely, the sum of intermediate consumption ($P_M M$), compensation of employees ($P_L L$), and consumption of fixed capital (CFC). As a result, the net operating surplus (NOS) for the education sector is implicitly set to zero, which is more or less in accordance with the notion that the government or NPISHs should serve as non-profit institutions.

This input-based approach for measuring the output has long attracted comprehensive discussions and debates, primarily because of its deficiency for productivity analysis (e.g. Hill, 1975; Eurostat, 2001; Atkinson, 2005; Abraham and Mackie, 2005). More recently, based on the economic approach toward index numbers, and differing from the traditional way to measuring productivity, a novel cost-based volume index of output is suggested for constructing the cost-based productivity measure that is considered a valid indicator of technical change for non-market producers (see Diewert, 2008; Schreyer, 2012).

Distinct from the more conventional view that the output of education sector is education services, there is a widespread notion that the output should be considered as investment in human capital, based on apparent observations that education generates knowledge, skills and competencies that are the source of future benefits to be accrued to individuals taking current education, which bears full analogy to investment in physical capital.

Although not explicitly, and because of this, sometimes confusing, this notion has an important implication that the focus of producers in analysis should better be shifted from the education sector as a whole to the individuals who are personally taking education provided by the education sector for the purpose of developing knowledge and competencies. More on this later in Section 3.

Treating the output of education sector as investment in human capital rather than education services, there are in general two ways to measure this output in the literature: the cost-based and the income-

[3] This convention can at least be traced back to the early UN version of the SNA, e.g. the SNA 1953 (United Nations, 1953).

based approaches.[4] The cost-based approach measures the investment in human capital as the sum of total inputs devoted to education (e.g. Kendrick, 1976), which is similar with the way the output of the education sector is measured in the SNA as outlined above. There are, however, significant differences between them.

Since the focus of producers has shifted from the education sector to the individuals who are taking education, the total inputs should include not only the cost of production in the education sector (i.e. $P_M M + P_L L + CFC$), but also the cost of inputs used by individuals, in the form of households final consumption expenditure for the purpose of education. The former that is technically considered as consumed by government or NPISHs (i.e. final consumption expenditure by government or NPISHs) plus the latter yield households *actual* final consumption for the education purpose (United Nations *et al*., 2009).

In addition, on the top of the households *actual* final consumption for the purpose of education, the economic value of own time inputs (for studying) by individuals themselves are sometimes added, measured usually by the forgone earnings for students when taking education, in order to form the final measure of human capital investment based on the cost-based approach (e.g. Kendrick, 1976; Eisner, 1988).

By denoting the value of the gross output of the education sector, now regarded as the human capital investment and measured by the cost-based approach, as $P_H^C H^C$, one yields:

$$P_H^C H^C = P_E E + HFC_E + P_{\tilde{L}} \tilde{L} \quad (2)$$

where

P_H^C: Price of investment in human capital, by the cost-based approach;

H^C: Volume of the corresponding investment in human capital, by the cost-based approach;

HFC_E: Household final consumption for the purpose of education;

$P_{\tilde{L}}$: Price of own labor service used for studying;

$\tilde{L}$: Volume of the corresponding own labor service.

[4] Strictly speaking, there are more approaches to measuring human capital, but these two monetary measures are considered the most promising ones to be included in the SNA in the future. For the pros and cons of various approaches for measuring human capital, see e.g. Liu and Fraumeni (2014).

Differing from the cost-based approach, the income-based approach measures the output of education sector as increments to lifetime incomes of the individuals taking education (e.g. Jorgenson and Fraumeni, 1992a, 1992b). The lifetime income is calculated as the present value of the expected future labor incomes that could be generated over one's lifetime due to education.

Both the cost-based and the income-based approaches have theoretical appeals and bear certain similarities with the way the assets are measured in the SNA. For instance, the cost-based approach is in line with the Perpetual Inventory Method (PIM) that is widely used for measuring the stock value of traditional produced capital, while the income-based approach is in accordance with the Net Present Value (NPV) method that is usually applied for some other assets (e.g. natural resources).

The estimates of human capital derived from the two approaches are expected to be approximate with each other in an ideal world. In reality, however, the estimates by the income-based approach are found to be larger than those by the cost-based approach with a significant margin.[5]

3. The satellite account for human capital

Although the OECD definition of human capital has gradually received wide acceptance, principally because of the comprehensiveness of its definition domain, as well as the value of serving as an internationally comparable reference (see Section 1), measuring human capital in practice, however, has to follow a stepwise approach by focusing on a narrower scope as a point of departure (Liu and Fraumeni, 2014).

Taking this approach, the satellite account that is presented in this paper will focus on the valuation of the elements that are associated with the *economic returns* due to *formal education* that is provided by the education sector, as well as *training and courses* that are provided by employers to employees.[6] This is first to sidestep various conceptual and methodological issues by involving non-economic dimensions,[7] and second, to be in more accordance with the current core system of the SNA. Recognizing that human capital is currently outside of the SNA, and straight incorporation of it is bound to change the entire national accounting system fundamentally, a more pragmatic way is

[5] An interesting discussion on the possible reasons behind the large discrepancies of the human capital estimates based on the cost-based and the income-based approaches can be found in e.g. Abraham (2010).

[6] Expenses for training and courses provided by employers to employees are treated as intermediate consumption in the current SNA (e.g. United Nations *et al*., 2009).

[7] Discussions on the issues associated with non-market dimensions in the field of human capital measurement can be found in e.g. Liu (2014).

therefore to start with the construction of experimental satellite account for human capital, in order to reduce as much as possible the impact on the whole system, and meanwhile, to establish a coherent and consistent framework for further research (Abraham and Mackie, 2005; United Nations *et al*., 2009; Boarini *et al.*, 2012).

A satellite account is a framework designed to expand the analytical capacity of, while at the same time, to maintain the link to, the core SNA accounts without overburdening them or interfering with their general-purpose orientation. Experimental satellite accounts for human capital in general, and for the education sector in particular, have been compiled in several countries (e.g. Jorgenson and Fraumeni, 1989; Di Veroli and Tartamella, 2010; Gu and Wong, 2010; Bos, 2011).

As regards the measuring methodology of human capital in these studies, either the cost-based or the income-based approach was applied, but no effort has ever been found trying to bring these two approaches within one and the same framework of a satellite account for human capital in a consistent way, and accordingly to reconcile the differences between the estimates based on these two different approaches. This paper aims to make the effort.

In the satellite account for human capital to be presented in the paper, the generation of human capital is regarded as a production process that is undertaken by individual persons when taking formal education or training and courses; the product of this production activity is the investment in human capital asset, to be added to the human capital stock that is already accumulated and embodied in the person in concern. As such, both the conventional production and asset boundaries of the SNA are extended.

Let us consider a production account for an individual taking formal education (e.g. primary education):

(3)
$$P_H^I H^I = P_{\tilde{M}} \tilde{M} + P_{\tilde{L}} \tilde{L} + GOS_H$$
$$P_{\tilde{M}} \tilde{M} = P_E E + HFC_E$$

where

P_H^I: Price of investment in human capital, by the income-based approach;

H^I: Volume of the corresponding investment in human capital, by the income-based approach;

$P_{\tilde{M}}$: Price of total intermediate consumption used by the individual for the production of human capital investment;

$\widetilde{M}$: Volume of the corresponding intermediate consumption;

GOS_H: Gross operating surplus accrued to the individual as a producer of human capital investment.

In equation (3) the individual person is explicitly treated as one entrepreneur (or one production unit). Formally, the total value of human capital investment produced by the individual taking a specific education ($P_H^I H^I$) equals the sum of the total intermediate consumption ($P_{\widetilde{M}}\widetilde{M}$), compensation of employees ($P_{\tilde{L}}\tilde{L}$), and gross operating surplus (GOS_H).

The total intermediate consumption ($P_{\widetilde{M}}\widetilde{M}$) is the sum of two items: the first is education service provided by the education sector ($P_E E$), i.e. the output of education sector conventionally measured within the framework of the SNA (see equation (1)); and the second is all other intermediate consumptions, i.e. household final consumption expenditures for the purpose of education (HFC_E), such as expenses on school fees, books, and other educational materials.

Within this new framework, the value of compensation of employees ($P_{\tilde{L}}\tilde{L}$) refers actually only to the labor compensation to the individual him/herself in his capacity as a self-employed person working for producing human capital investment, in other words, it is the remuneration for own labor services used in the production process.

Note that the sum of the total intermediate consumption ($P_{\widetilde{M}}\widetilde{M}$) and the remuneration for own labor services ($P_{\tilde{L}}\tilde{L}$) in the production of investment in human capital is equal to the value of human capital investment measured by the cost-based approach, as shown in equation (2) in Section 2. Then, by inserting equation (2) into equation (3), one can easily find that

$$GOS_H = P_H^I H^I - P_H^C H^C. \tag{4}$$

Equation (4) indicates that the differences between the two estimates of human capital investment respectively by the income-based approach ($P_H^I H^I$) and the cost-based approach ($P_H^C H^C$) is equal to the gross operating surplus (GOS_H) generated from the production process of human capital investment by the individual who is seemingly taking education service, while actually producing human capital investment at the same time.

There may be a host of reasons behind the differences that are found between the estimates of human capital by the two approaches. We shall not dwell on the aspects of them with detailed investigation

here, which is clearly beyond the scope of this paper. Arguably, however, it will be easier to explore these issues when a framework is established with both approaches included in a consistent way, such as the one as shown in the paper.

Within the new satellite account for human capital, it has been explicitly stated that it is the individual person taking education or training and courses, rather than the entire education sector that is the genuine producer of the human capital investment generated from the production process. This is consistent with the view that no one else can conduct the same production process (through learning, studying and practicing) on behalf of the individual him/herself.

Accordingly, it is rather natural to think that the gross operating surplus (GOS_H), derived after the intermediation consumption ($P_{\tilde{M}}\tilde{M}$), and the compensation of employees ($P_{\tilde{L}}\tilde{L}$) are deducted from the total output ($P_H^I H^I$),[8] should be allocated to the individual entrepreneur dealing with the production of human capital.

In other words, the individual person should be entitled as having the right for residual claims of this production unit specializing in the production of human capital. As a result, the individual person should be considered as possessing the ownership of human capital accumulated through such investment activity. Although it is hard to separate the individual person from the human capital accumulated and embodied, the treatment is more in line with the common view about how human capital is developed and where it is embodied.

Non-separability of an asset from that it is attached does not necessarily lead to the exclusion of the asset from the SNA. For example, goodwill and marketing assets are those that cannot be separated from the firms they are attached, thus, these assets have to be dealt with in its entirety with the firms as a whole, i.e. including both the equity assets of the firms and the goodwill and marketing assets that can only be realized through market transactions.

Likewise, non-separability of an asset from its owner should not either give rise to any difficulties that prevent human capital to be regarded as an asset within the SNA. Because the two necessary conditions that an entity should qualify as an asset by the SNA are, first, an asset must be owned by some unit, or units, and second, from which economic benefits are derived by their owner(s) by

[8] For the sake of simplicity, other (non-human) capitals either owned or rented from outside (e.g. personal computers, software, etc. used for studying) by the individual in concern are assumed away from the human capital production process.

holding or using them over a period of time (e.g. United Nations *et al*. 2009), clearly, human capital fulfils both conditions.

More often than not, the estimates by the income-based approach are larger than those by the cost-based approach, resulting in positive gross operating surplus (GOS_H). But it does not imply that it is uncommon or impossible for GOS_H to be negative for a specific individual. In that case, the GOS_H will be interpreted as gross operating losses.

Whether it is gross operating surplus or losses, the point is that the treatment as illustrated in the satellite account is in line with the theory of investment since investment in human capital is a risky activity, implying that such investment may lead to either gains or losses accrued to the individual person as current investor, a result that can only be seen in the realized future.

There is another advantage by treating the individuals, rather than the entire education sector, as the producer of human capital, because this realistic view is in accordance with the concepts with which the national accountants are familiar.

By the jargon of national accounting, education services are the 'output', while the human capital investment due to education is the 'outcome' out of the education sector. The output refers to goods and services that directly result from a production process undertaken in economic units such as educational institutions. Under circumstances where no quality change is involved, a first approximation of the output of education sector can be captured by observed processes or activities such as the number of teaching hours (see Schreyer, 2010, 2012).

On the contrary, the outcome is a *state* that is valued by consumers, such as the human capital that is developed and reflected by the level of knowledge generated through learning, studying and practicing in educational institutions. A production process undertaken by the education sector can not only generate the output, but also lead to a number of outcomes, including direct (e.g. credit points and test scores) and indirect (e.g. economic and non-economic benefits to people by taking education) outcomes.

The distinctions between the output and the outcomes are that the outcomes are influenced by many factors, including the quantity and quality of the output itself; while the provision of the output (e.g. education services) refers closely to the activities or processes that are within the production boundary

of the SNA, the outcomes are further away from this provision, with indirect outcomes being even further than direct outcomes.

Simply because more and more factors (e.g. innate abilities, cultural, social, and economic backgrounds, as well as political, legal and institutional arrangements) will play a part in the transition from the output to the outcomes, neither direct nor indirect outcomes are considered to be proper measures of the output of the education sector by national accountants (see Schreyer, 2012; Liu and Fraumeni, 2015).[9]

This conventional view justifies to some extent the choice made in the satellite account for human capital as presented in the paper. In other words, the output of the education sector represented by education services should remain to be dealt with in the framework of the SNA, while human capital investment as the outcome of the production of education services should be considered as an output of anther production process, i.e. the production of human capital investment by individuals taking education. The merging of the two actually distinct production processes will make the interpretation of the estimation results, and the associated productivity analysis more difficult (e.g. Schreyer, 2012).

The framework of the satellite account for human capital as presented in the paper is flexible enough to embrace as well the education services that are provided by market producers and purchased by individuals. Formally, all these expenses can be covered by the household final consumption expenditure for the purpose of education (HFC_E).

Moreover, the total intermediate consumption used for the production of human capital investment ($P_{\tilde{M}}\tilde{M}$) covers the relevant expenses that are mainly market inputs, such as tuition fees, training costs, books and materials, etc.; however, it can well be extended to cover non-market inputs such as books and materials donated by others. Similarly, the compensation of employees ($P_{\tilde{L}}\tilde{L}$) can be extended to cover those non-market time inputs that are provided by others, such as the time inputs by parents and other volunteers for helping individuals for studying.

In terms of economic evaluation of the accounting elements in the satellite account, for education services and training and courses that are provided by the market producers, market prices can be used for evaluating the economic value of these services. However, when education services are provided

[9] However, information about either direct or indirect outcomes, in particular, about the contribution of education services to these outcomes, can provide a tool for the explicit quality adjustment of the output of educational sector (Schreyer, 2010).

by non-market producers with no market prices observed, the value of these services should be estimated by summing the total costs, as suggested by the SNA.

Based on the time use surveys, the economic value of own time input for studying by the individual in concern can be estimated by the 'opportunity cost approach', i.e. to measure it at his/her market wage rate, such as foregone earnings due to studying instead of working somewhere else. While for the value of the time inputs by parents and other volunteers for helping studying, the 'replacement cost approach' may be employed, i.e. to measure the value at the specialist wage, possibly adjusted to reflect skill and effort difference between market and non-market production (see Abraham and Mackie, 2005).

As mentioned above, the output of the individual dealing with the creation of human capital is regarded as the new human capital investment, which can be valued by the income-based approach, to be more precisely, by the lifetime income approach, calculated as the lifetime earnings' differential due to this new investment, e.g. one accounting year's studying.

For facilitating a better understanding of the new framework of the satellite account for human capital, in which both the cost-based and the income-based approaches, the two most promising approaches to measuring human capital are reconciled, a numerical example, based on hypothetically simple economy with fictitious figures, will be given in the following section.

4. A numerical example

In this section, supply and use tables are applied for further illustrating the points discussed in Section 3. First, supply and use tables that are in accordance with the current SNA are presented. The new supply and use framework with human capital included is then presented and compared with the old one, with the associated changes being highlighted.

4.1. Supply and use tables within the SNA

As an example, the supply and use tables (both with the structure of two dimensions, i.e. *product x industry*) for a hypothetical economy are displayed in Table 1 and Table 2, respectively. For the sake of simplicity, there are neither imports nor exports in this simple economy.

In the tables, products are divided into two groups: human capital related products (named as '*Education*' in Table 1 and Table 2) and other products. The human capital related products are further

divided into several categories: *pre-primary*, *primary*, *secondary* and *tertiary* for formal education services, and *training & courses* that are provided by employers to employees.

The industries in this simple economy are dichotomously divided into two broad categories: education service providers and other industries that produce goods and services other than education services. The former is further divided into *Market producer*, *Government* and *NPISHs*.

Table 1. Supply table (traditional)

	Industries				Imports	Total supply
	Other industries	Education by				
		Market producer	Government	NPISHs		
Products						
Other products	100	0	0	0	0	100
Education						
Pre-primary	0	2	3	2	0	7
Primary	0	2	3	2	0	7
Secondary	0	2	3	2	0	7
Tertiary	0	2	3	2	0	7
Training & courses	0	3	0	0	0	3
Total output	100	11	12	8	0	131

The supply table (Table 1) provides information about how many different products are supplied by the corresponding suppliers. For example, the market producer is supplying 2 units for each level of formal education services (*pre-primary*, *primary*, *secondary* and *tertiary*) and 3 units of *training & courses*. The government and the NPISHs are assumed only to provide formal education services, with the former providing 3 units and the latter 2 units for each level of formal education services. In sum, the total output from this simple economy is 131 units, consisting of 31 units of human capital related products and 100 other products.

Table 2. Use table (traditional)

	Industries				Final use					Total use
	Other industries	Education by			Final consumption by			GCF	Export	
		Market producer	Govern-ment	NPISHs	House-holds	Govern-ment	NPISHs			
Products										
Other products	60	5	5	5	5	5	5	10	0	100
Education										
Pre-primary	0	0	0	0	2	3	2	0	0	7
Primary	0	0	0	0	2	3	2	0	0	7
Secondary	0	0	0	0	2	3	2	0	0	7
Tertiary	0	0	0	0	2	3	2	0	0	7
Training & courses	3	0	0	0	0	0	0	0	0	3
Total use	63	5	5	5	13	17	13	10	0	131
Value added	*37*	*6*	*7*	*3*						
Compensation of employees	30	3	6	2						
Other net taxes on production	0	0	0	0						
Consumption of fixed capital	3	1	1	1						
Net operating Surplus	4	2	0	0						
Total output	100	11	12	8						

In the use table (Table 2), the formal education services supplied by the market producer (2 units for each category) are absorbed as final consumption by the households sector within the framework of the current SNA, except for the *training & courses* (3 units); the latter is used by other industries as intermediate consumptions because the costs of training and courses are usually covered by employers in other industries on behalf of their employees.

As outlined in Section 2, according to the SNA convention, the education services provided by non-market producers are treated as final consumptions absorbed by themselves, i.e. the government and the NPISHs, although in the detailed accounts, this part of final consumption will be treated as transferred by the government and the NPISHs to the households sector as part of their *actual* final consumptions.

To produce education services, the corresponding industries will also use some other products as intermediate inputs. As shown in Table 2, 5 units of other products are assumed to be used in each of the education related industries, i.e. the market producer, the government and the NPISHs. Likewise, some other products are also used as final consumptions by households sector, the government and the NPISHs. In addition, 10 units of other products are assumed to be used as gross capital formation (GCF) in the economy.

When looking at the components of the panel of value added in Table 2, it has been mentioned in Section 2 that the operation surplus for the non-market producers (the government and the NPISHs) is usually assumed to be zero according to the SNA convention. Another assumption made here is that there are no other taxes (net of subsidies) on production, merely for the sake of simplicity.

Although the settings presented here are simple, it can be confirmed that the following identities for both the industries and the products are observed: output by industry = input by industry; total supply by product = total use by product.
Moreover, based on the simple settings as presented so far, GDP for this simple hypothetical economy can be calculated as follows:

- By the production approach, GDP = total output (131) - intermediate consumption (63 + 5 + 5 + 5) = 131 - 78 = 53.
- By the income approach, GDP = compensation of employees (30 + 3 + 6 + 2) + other net taxes on production (0) + consumption of fixed capital (3 + 1 + 1 + 1) + net operating surplus (4 + 2 + 0 + 0) = 41 + 0 + 6 + 6 = 53.
- By the expenditure approach, GDP = final consumption by households (13) + final consumption by government (17) + final consumption by NPISHs (13) + gross capital formation (10) + net export (0) = 13 + 17 + 13 + 10 + 0 = 53.

Within the framework of the SNA and reflected by Table 1 and Table 2, the output of the entire education sector is calculated as the sum of two items: expenses for training and courses that are treated as part of intermediate consumption and are bought from and provided by the market producers (3 units), and households actual final consumption for the purpose of education.

The second item is again the sum of households final consumption expenditure for the purpose of education that is purchased from and provided by the market producers (8 unites), and the final consumption expenditure for the purpose of education by non-market producers (government and NPISHs) on behalf of households (12 units + 8 units). In total, the value of the output of the education sector in this simple economy is therefore 31 units.

4.2. Extended supply and use framework with human capital as a ‘produced’ product/asset

In this subsection, human capital as a ‘produced’ asset is added to the supply and use tables. By treating an individual person as an entrepreneur that is the producer of human capital product, we have to add one new industry in the supply table (see Table 3). This new industry is called ‘individuals

taking education' and supplies investment in human capital classified by the categories corresponding to the different types of education services (10 units for each and 50 units in total). Therefore, the corresponding products (*HC investment*) are also added in the table (see Table 3).

Table 3. Supply table (extended)

	Industries					Imports	Total supply
	Other industries	Education by			Individuals taking education		
		Market producer	Government	NPISHs			
Products							
Other products	100	0	0	0		0	100
Education							
Pre-primary	0	2	3	2		0	7
Primary	0	2	3	2		0	7
Secondary	0	2	3	2		0	7
Tertiary	0	2	3	2		0	7
Training & courses	0	3	0	0		0	3
HC investment							
Pre-primary					10		10
Primary					10		10
Secondary					10		10
Tertiary					10		10
Training & courses					10		10
Total output	100	11	12	8	50	0	181

Compared with Table 1 (the supply table within the SNA), except for the changes as mentioned above, there are no other changes. However, the total output from the simple economy will become 181 units, a 50 units' increase due to the extension of the production boundary.

As for the use side, there are more changes if compared with the original use table (Table 2). Being the producers of human capital, the new industry of 'individuals taking education' now receives as intermediate consumptions all the education services provided by the market producer, the government and the NPISHs. In other words, the education services absorbed previously as final consumptions by the households sector, the government and the NPISHs in Table 2 will be reclassified as intermediate consumptions in the new human capital production industry.

The new industry of 'individuals taking education' also uses some of other products (e.g. books and materials) as intermediate consumptions. As a result, the original final consumptions of other products by households sector as shown in Table 2 (5 units) are assumed to be divided into two parts, 1 unit goes into intermediate consumption in the new industry and 4 units remains as final consumption by the households sector.

Another important change as shown in Table 4 is that under the headings of GCF (gross capital formation), one new column is added with the title of 'HC' (standing for human capital investment). As shown in Table 4, the different categories of human capital products (*pre-primary*, *primary*, *secondary* and *tertiary*, and *training & courses*) enter into the new category of HC as human capital formation by the corresponding categories. The value of these human capital investments are estimated by the lifetime income approach and are assumed to be 10 units for each and 50 units in total.

Table 4. Use table (extended)

	Industries					Final use						Total use
	Other industries	Education by			Individuals taking education	Final consumption by			GCF		Export	
		Market producer	Govern-ment	NPISHs		House-holds	Govern-ment	NPISHs	Other assets	HC		
Products												
Other products	60	5	5	5	0	5	5	5	10		0	100
Education												
Pre-primary	0	0	0	0	7				0		0	7
Primary	0	0	0	0	7				0		0	7
Secondary	0	0	0	0	7				0		0	7
Tertiary	0	0	0	0	7				0		0	7
Training & courses	0	0	0	0	3	0	0	0	0		0	3
HC investment												
Pre-primary										10		10
Primary										10		10
Secondary										10		10
Tertiary										10		10
Training & courses										10		10
Total use	60	5	5	5	31	5	5	5	10	50	0	181
Value added	*40*	*6*	*7*	*3*	*19*							
Compensation of employees	33	3	6	2	3							
Other net taxes on production	0	0	0	0	0							
Consumption of fixed capital	3	1	1	1	0							
Net operating Surplus	4	2	0	0	16							
Total output	100	11	12	8	50							

In Table 2, there are 3 units of 'training & courses' being treated as intermediate consumptions used by other industries. By assumption, they are produced by the market producers and the costs are covered by the employers of other industries. In Table 4, these 3 units of 'training & courses' are reclassified as compensation of employees in kind and are further used directly for buying 'training & courses' by the new industry of 'individuals taking education' in order to produce the human capital investment in 'training & courses'. As a result, the intermediate consumptions for other industries

decreases with 3 units, while the compensation of employees in the ‘other industries’ increases with the same amount.

Finally, the new industry of ‘individuals taking education’ uses 31 units as intermediate consumptions (28 units of formal education services and 3 units of training & courses) and produces 50 units of products as human capital investments in different categories. The value added from this new industry is 19 units, consisting of 3 units of compensation of employees due to own time input for studying. As a residual, the operating surplus for this new industry of ‘individuals taking education’ is 16 units.

In sum, in the new supply and use framework with human capital included as a produced product/asset, the two identities as observed in the original supply and use tables (Table 1 and Table 2) are still hold, i.e. output by industry = input by industry; total supply by product = total use by product.

In addition, GDP for this simple hypothetical economy can be recalculated as follows:

- By the production approach, GDP = total output (181) - intermediate consumption (60 + 5 + 5 + 5 + 31) = 181 - 106 = 75.
- By the income approach, GDP = compensation of employees (33 + 3 + 6 + 2 + 3) + other net taxes on production (0) + consumption of fixed capital (3 + 1 + 1 + 1 + 0) + net operating surplus (4 + 2 + 0 + 0 + 16) = 47 + 0 + 6 + 22 = 75.
- By the expenditure approach, GDP = final consumption by households (5) + final consumption by government (5) + final consumption by NPISHs (5) + gross capital formation (10 + 50) + net export (0) = 5 + 5 + 5 + 60 + 0 = 75.

By incorporating human capital into the production and asset boundaries of the SNA, the GDP of the economy has increased from 53 to 75 units, the difference of which (22 units) consists of two parts: the first is the value added generated from the production of human capital (19 units), and the second is the inflated value added generated from other industries, due to the in creased compensation for employees (by 3 units) that are previously treated as intermediate consumption within the framework of the SNA.

Note that the value added generated from the new industry of ‘individuals taking education’ dealing with the production of human capital (19 units) is itself the sum of two parts: the first is the compensation of employees of 3 units (i.e. remuneration for own labor services used in the production process), and the second is the operating surplus claimed by the individuals (16 units).

Finally, it is easy to confirm that equation (4) holds for this simple economy as well. In other words, the 16 units of the operating surplus is equal to the difference of two estimates of human capital investment developed in the economy in that the estimates by the income-based approach are 50 units, while those by the cost-based approach are 34 (31 + 3) units (see Table 4).

5. Concluding remarks

By treating the creation of human capital as a production activity by the individuals taking education and/or training and courses, and the output of this production as a new product of investment in human capital, this paper presents a satellite account for human capital that extends the production and asset boundaries of the current SNA.

Within the satellite account, the inputs for producing human capital by the individuals include the education services provided by the education sector that are traditionally considered as the output of the education sector within the framework of the SNA.

In addition, a fundamental and decisive input for producing human capital is own labor services by the individual that are reflected by the own time input used for learning, studying and practicing during the production process of human capital. Mainly because of this, the gross operating surplus from the production of human capital is allocated to the individual in concern. Accordingly, the developed human capital through this production process is regarded as being owned by the individual him/herself.

More important, the gross operating surplus generated by the production of human capital is demonstrated as being equal to the differences between the estimates by the cost-based and the income-based approaches. Thus, the new framework as presented in this paper makes an effort towards the reconciliation of the two most promising approaches to measuring human capital in the field.

By means of a simple supply and use framework with human capital as a produced asset, as well as a numerical example based on it, this paper shows how to register the new product of human capital investment, and accordingly the relevant changes due to the inclusion of human capital as a product/asset into the SNA. The results are compared with an old framework that is in accordance with the current SNA.

As said, the setting as presented so far is simple, which can certainly be extended in several directions by taking on board more interesting issues related to human capital accounting. For instance, the new industry of ‘individuals taking education’ introduced in the paper may be further divided into ‘students taking education’ and ‘employees taking training and courses’.

For the former, human capital accumulated can be recorded as work-in-progress, because the students are out of the current labor force. Once they enter into the labor force, their accumulated human capital can be registered as a negative change in stocks and as fixed capital formation by the same amount. While for the group of the employees, their human capital investments will be directly registered as fixed capital formation.

Many types of trainings and courses are not bought from the market. On the contrary, they are frequently carried out internally within the working units. As shown in the new framework in this paper, these expenses by the employers can be registered as compensation of employees in kind and are then used by employees for producing human capital investment.

In the current framework, no imports or exports are taken into account. However, it is easy to cover both imports and exports within the same framework. For example, domestic human capital investments can come from taking imported education services as inputs, while domestic education services can also be bought by non-residents. Furthermore, migration of people with human capital embodied can explicitly change the stock level of human capital in a country.

Last but not least, it merits to be mentioned that the basic framework as presented in the paper can be very well applied to another important type of asset, i.e. health capital, which is sometimes regarded as the output of health sector, but should actually be considered as generated by investment activities conducted by the individuals themselves, in quite the same way as human capital is developed.

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