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Keywords: National Accounts, Human Capital

JEL classification: E10, I26, J24

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Measuring Human Capital in the UK Economic Accounts: An experimental satellite account.

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Abstract

The Office for National Statistics (ONS) has for over 10 years produced annual stock estimates of human capital assets, in real and nominal terms with a variety of demographic decompositions. Similarly, most published papers from both academic and national statistical institutions have focused on the production and analysis of human capital stock estimates. This paper looks to move beyond this by considering the economic flows associated with incorporating human capital assets into the UK Economic Accounts within the context of an experimental satellite account; thereby explaining the movement between two human capital stock positions and the resulting effect on the main national accounts aggregates such as gross value added, savings, net worth, etc. In doing this we draw on the UNECE Guide to measuring human capital (UNECE; 2016) and the examples of the Human Capital Accounts produced by Canada and the United States, as its starting points for integrating the "production" of human capital assets into the economic accounts and then looks at extending that to include the production of services arising from those human capital assets by looking at parallels with how the System of National Accounts treats other produced assets used within a production process where the economic ownership of the asset resides with another institutional unit. This constitutes a key contribution to the existing body of work, and the estimates presented here are the first of their kind for the UK and demonstrates the importance of human capital assets for the economic accounts due to their magnitude in comparison with current total non-financial assets on the UK balance sheet; on average human capital assets are 220% of total non-financial assets for the reference period 2005-2018.

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1. Introduction

The Office for National Statistics (ONS) has for over 10 years produced annual stock estimates of human capital assets, in real and nominal terms with a variety of demographic decompositions.[2]

[1] With thanks to Richard Heys, Marianthi Dunn, Eurydice Fotopoulou, Steve Drew, Diane Coyle and Gueorguie Vassilev for their comments, and two anonymous referees. All errors remain the author's. All views are the author's and not necessarily the views of the Office for National Statistics.

[2] ONS published estimates of human capital are available at: https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/humancapitalestimates/2004to2018

Similarly, most published papers from both academic and national statistical institutions have focused on the production and analysis of human capital stock estimates. This paper looks to move beyond this by considering the economic flows associated with incorporating human capital assets into the UK Economic Accounts within the context of an experimental satellite account; thereby explaining the movement between two human capital stock positions and the resulting effect on the main national accounts aggregates such as gross value added, savings, net worth, etc. In doing this we draw on the UNECE Guide to measuring human capital (UNECE; 2016) and the examples of the Human Capital Accounts produced by Canada and the United States, as its starting points for integrating the "production" of human capital assets into the economic accounts and then looks at extending that to include the production of services arising from those human capital assets by looking at parallels with how the System of National Accounts treats other produced assets used within a production process where the economic ownership of the asset resides with another institutional unit. This constitutes a key contribution to the existing body of work, and the estimates presented here are the first of their kind for the UK, even with the acknowledged shortcomings in the experimental estimates, and demonstrates the importance of human capital assets for the economic accounts due to their magnitude in comparison with current total non-financial assets on the UK balance sheet; on average human capital assets are 220% of total non-financial assets for the reference period 2005-2018.

The paper also looks to address the points raised by Bucknall *et al.* (2021), concerning the integration of human capital as part of the 'Spectrum' of adjusted aggregates which aspires to tell a more complete economic welfare picture when compared to gross domestic product alone, as we develop our conceptual sequence of economic accounts for the UK human capital satellite account. The points raised by Bucknall *et al.* (2021) concerning human capital were:

- If human capital is a capital, it must be created through investment. One therefore needs to identify the process by which this investment occurs. Clearly education output would be one source, but also business and household spending on adult education, on-the-job training and apprentices, and sector specific training would need to be captured within our estimate of human capital investment. While business training would be captured in the existing estimates of uncapitalised intangibles incorporated into (*Bucknall's proposed measure of*) NNDI+, one would need to resolve how the entirety of this educational investment is converted into capital as education is a long and complicated process. For example, would primary school spending in year 1 be treated as capital investment in year 1, or as 'work in progress' until the child has completed their school career and joined the labour force?
- If human capital is a capital, what is the rate of return and where would this be observed? One would need to review compensation of employees and disaggregate this into a return to labour and a return to human capital.
- Importantly, how would one account for depreciation (e.g., skills eroded through unemployment hysteresis), depletion (e.g., untimely death whilst still in the labour force), and retirement (e.g., people leaving the labour market as they reach the end of their career)?
- If one captures retirement, how then does one account for human capital deployed in the household, either during retirement or before?
- Does one adjust the human capital stock for the health of the workforce?
- How does one account for imports (immigration) and exports (emigration)?

Bucknall et al. (2021); p14.

The theoretical discussion within this paper considers these points through setting out the economic flows required to move from one human capital stock position to another within the framework of a human capital satellite account.

The next section considers why measuring human capital is important (Section 2), which is then followed by how it has been defined at different points in time (Section 3), then the bulk of the paper is spent discussing the compilation of a UK experimental human capital satellite account both theoretically (Section 4) and practically with some early estimates of the required economic flows and stocks (Section 5). These two sections constitute a key contribution to the existing body of work, and the estimates presented here are the first of their kind for the UK. The penultimate section then moves on to consider how human capital assets would be incorporated into multi-factor productivity and the necessity of an age-efficiency profile for human capital, to allow the estimation of productive human capital stocks and associated human capital services. This need for an age-efficiency profile for productivity analysis is solved by reference to the work of O'Mahony and Samek (2021) on the relationship between human capital and health. The results presented by O'Mahony and Samek (2021), varied by qualification level, gender and age, with productive human capital stock being reduced by about 45% for individuals aged 50 years or older with low qualifications. This finding alone underscores the need to correctly estimate the productive human capital stock to correctly allocate its contribution within multi-factor productivity analysis. This paper then closes with some conclusions and highlights the areas of further research which would improve the UK's experimental human capital satellite account in the future.

2. Purposes of measuring human capital

Producing statistics on human capital can serve many purposes, from better understanding what drives economic growth, to assessing the long-time sustainability of a country's development path, measuring the output and productivity of the education sector and to understanding further the underpinnings of income distribution.

The modern concept of human capital has its origins in the economic growth literature, as economists tried to explain the "puzzle" of economic growth based on conventional production functions of labour inputs and capital; that is the large size of the residual explained by neither produced capital nor labour inputs. The first step was to see the investment in human capital, through education, training, and work experience as enhancing the quality of the quantity of labour inputs, therefore explaining some of the residual (Schultz; 1961). This was followed by the new growth models, which proposed that investment in human capital did not just improve the quality of the labour input but that it engendered positive externalities of technological progress and innovation (Lucas, 1988; Romer, 1990; Barro and Sala-i-Martin, 1995). Recent, improved data on educational attainment have made more robust estimates of the impact of human capital on economic growth possible suggesting a sizable impact of human capital accumulation on economic growth (see Arnold et. al., 2007; Sianesi and Van Reenen, 2003).

Assessment of inter-generational sustainability usually requires that an unchanged stock of total capital (including human capital) per capita to be passed on to the next generation. Given the assumption of substitution between different types of capital within a production function, a common measurement metric is therefore required, i.e. monetary valuation. This equally requires a robust methodology for estimating the monetary value of human capital. Due to its importance in

most advanced economies, understanding the effects of an aging population on human capital accumulation is important for making policy decisions on the sustainability of the total stock of capital per capita.

The value of the economic production of the education sector is conventionally measured on a sum of costs basis, that is the costs of the market inputs that are used in this sector. These costs include teachers' wages and salaries, the consumption of fixed capital (e.g. due to the use of school buildings), household expenditures for school fees and educational material, etc. This input-based approach is inadequate for productivity analysis since it ignores changes in the efficiency with which various inputs are used in production, or changes in their effectiveness in delivering outputs or outcomes (Foxton *et al,* 2019). Improvements to the productivity analysis of the education sector can be made by using an output-based measure of its economic production. If we take the production of the educational sector to be the annual addition to the stock of human capital, a productivity measure for the sector could be established by comparing changes in the volume of inputs and changes in the volume of outputs. Separate measures of these two elements are therefore required and can be achieved by utilising the life-time income approach to measuring human capital.

Finally, understanding the distribution of human capital is also important, as empirical studies have shown that countries characterised by a more equal distribution of human capital also experience greater income equality (Alesina and Rodrik, 1992; OECD and Statistics Canada,2000).

The next section considers how human capital is defined and how this has changed over time and for our purposes the definition we will be using in the rest of this paper.

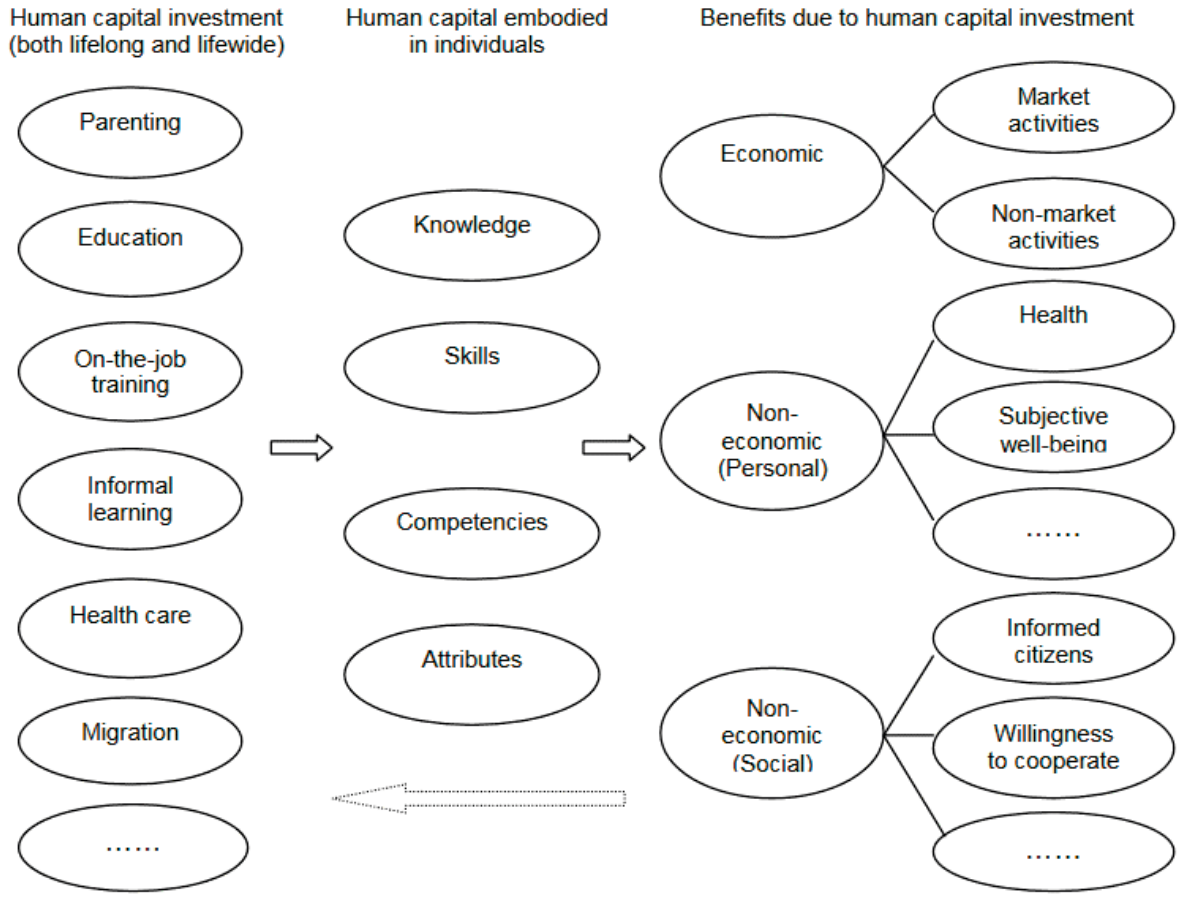
3. What is human capital?

The definition of human capital has not remained static over time (see Table 1). The basic definition given by Adam Smith in the 18th Century has evolved to focus on skills and knowledge acquired for economic gain, and the broader multi-faceted well-being-based interpretation. The broader human capital definition reflects the move to knowledge-based, globalised economies and that human capital investment is evidenced in a range of non-economic benefits, such as improved health status, enhanced personal well-being and greater social cohesion. This broader definition of human capital is represented in Figure 1.

Table 1: Selection of Human Capital definitions over time

Source	Definition of Human Capital
Smith (1776)	"…acquired and useful abilities of all the inhabitants or members of the society" …an individual will incur costs to obtain such abilities, once acquired they stand as "a capital fixed and realised, as it were, in his person"
Schultz (1961)	…acquired skills and knowledge
Penguin Dictionary of Economics (1984)	…the skills, capacities and abilities possessed by an individual which permit him to earn income
OECD (1996)	…the knowledge that individuals acquire during their life and use to produce goods, services or ideas in market or non-market circumstances
OECD (1998)	…the knowledge, skills, competences and other attributes embodied in individuals that are relevant to economic activity
OECD (2001)	…the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being
World Bank (2006)	…the productive capacity embodied in individuals, with special focus on its contribution to economic production
Fender (2012)	…the knowledge, skills, competencies and other attributes embodied in individuals or groups of individuals acquired during their life and used to produce goods, services or ideas in market circumstances.
Liu (2016)	…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.

Figure 1: Human capital: a sketch of its formation, composition and benefits generated



Source: UNECE (2016), quoting OECD (2001).

While the OECD (2001) definition of human capital is gaining wider acceptance, mainly due to its comprehensiveness, for practical reasons this paper focuses on the life-long human capital investment from education, on-the-job training and informal learning via work experience and the economic benefits of that human capital investment. This removes the need to estimate non-economic benefits or the interaction with social capital and aligns the work with the SNA which is focused on recording economic transactions and balance sheet positions. This definition also aligns with the definition used in UNECE (2016); the definition given in Fender (2012), is as follows[3]:

"…the knowledge, skills, competencies and other attributes embodied in individuals or groups of individuals acquired during their life and used to produce goods, services or ideas in market circumstances"

Fender (2012); quoting OECD (2001).

This definition also has the pragmatic benefit that costs of formal education are available from the current economic accounts, as is the expenditure on training and courses provided by employers to employees (as part of corporations' intermediate consumption). The current national accounts also

[3] This is a narrower definition of human capital than that now used by the ONS which defines human capital as: "knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being".
As given in the ONS human capital publication, which is available here: https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/humancapitalestimates/2004to2018

capture the expenditure on individual upskilling via evening classes, driving lessons, etc.; some of this human capital investment may or may not be used to produce goods, services or ideas under market circumstances and therefore as a cost would need to be considered by type before inclusion. Future research will hopefully move beyond this basic definition and expand the definition to fall more in line with OECD (2001) through the incorporation of unpaid household production, e.g., parental input, etc., and the interaction with social capital; see Scrivens and Smith (2013) concerning the measurement of social capital.

4. Human Capital Satellite Account: Theoretical economic flows

Human capital as an individual asset has not yet been incorporated into the System of National Accounts core accounts, which is the internationally recognised standard for the compilation of accounts suitable for measuring, monitoring, and analysing the economy and its constituents. There are two main arguments against its inclusion. One is attributed to the 'production boundary' and the other to the 'asset boundary', as stipulated by the System of National Accounts 2008 (United Nations *et al.*, 2009).

Firstly, human capital is usually acquired by learning, studying, and experience. These activities cannot be undertaken by anyone else on behalf of the person considered, and thus do not satisfy the 'third party criterion'[4] 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.

The second main argument is that human capital is embodied in an individual and 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 machinery and equipment. Therefore, it is practically difficult, if not impossible, to envisage a tradable "ownership right" in connection with people and as a result human capital is not treated by the SNA as an asset.[5]

While it is not currently possible to include human capital into the core system of accounts framework, the SNA allows for elaboration of the central framework within the context of a satellite account.

Following OECD (2012) we can define a satellite account as follows:

The goal of satellite accounts is to supplement the main aggregates of the central framework of the SNA with measures that give a different picture of the economic process. Satellite accounts are frameworks designed to expand the analytical capacity of the core SNA accounts without overburdening them or interfering with their general-purpose orientation. Satellite accounts organize information in an internally consistent way that suits the particular analytical focus at hand, yet they maintain links to the existing national accounts. They can add detail or other information about a

[4] See System of Accounts 2008 (United Nations et al. 2019) para. 1.42 for definition of the SNA production boundary. Due to its nature, human capital cannot be produced by a unit and brought to a market to be sold to an individual. It must be produced by the individual in which the human capital is embedded.

[5] This last point, concerning the embodied nature of an asset is not unique to human capital. It is also a feature of goodwill and marketing assets which are embodied in a business and only become identifiable when a transaction takes place, i.e. the value of goodwill is identified when a takeover takes place and the value of the company is in excess of the value of its constituent parts, which leads to the goodwill and marketing asset being recorded as a non-produced asset.

particular aspect of the economy, for instance integrating monetary and physical data. Or they can arrange information differently, by cutting across sectors to assemble information on both intermediate and final consumption. For example, satellite accounts could gather business expenditures on training (treated as intermediate consumption in the core accounts) and education–related expenditures by households and government. They can also rely on different classifications than those used in core accounts."

OECD; 2012; p26.

For the human capital satellite account this means expanding the SNA production and asset boundary, reclassifying some of the current transactions following this expansion and determining in which sector the human capital is produced, these are similar steps to those taken for research and development assets prior to their inclusion within the core national accounts in the 2008 SNA revision. Experimental satellite accounts for human capital have been compiled already by several countries (see Jorgenson and Fraumeni (1989); Di Veroli and Tartamella (2010); Gu and Wong (2010); and Bos (2011)).

The proposed experimental human capital satellite account looks to adapt the two main frameworks within the System of National Accounts 2008, namely, the supply and use framework and the institutional sector accounts framework. The institutional sector accounts framework covers a sequence of inter-connected accounts which covers the production, generation of income, allocation of primary income, secondary distribution of income, use of income, capital account and balance sheet.

4.1 Measuring human capital: Cost approach vs life-time income approach

As mentioned above, there are two main approaches to measuring human capital, the cost approach and the life-time income approach. Conceptually, these are both used on the basis that in a perfect market the market should invest in the production of an asset up until the marginal cost equates to the marginal benefit from expected future returns, and hence the two methods should deliver equivalent values. For a variety of well-recorded reasons this is not the case in the majority of economies (incomplete capital markets, lack of perfect foresight around the supply and demand for skills in future years, uncertainty around how students will convert inputs into outcomes – not every child achieves their predicted grades etc). As such, one is compelled therefore to consider which method most closely maps to the concept being targeted. Table 2 provides a summary of the pros and cons of each of the approaches.

Table 2: Pros and cons of cost approach and life-time income approach to measuring human capital

Cost approach		Life-time income approach	
Pros	**Cons**	**Pros**	**Cons**
• "money" is used as the metric • Expenditure based • In-line with the estimation of the majority of the other traditional produced assets in the SNA asset boundary lacking a market price	• Identification of expenditure to include is difficult • only supply-side based • the value of inputs is equal to the value of outputs • relies on an assumption regarding the rate of depreciation • fails to take account of the heterogeneity of individuals	• "money is used as the metric • In line with economic theory • Different inputs and outputs • better represents the relationship with productive capacity needed for future production • values human capital services as a result of the interplay of demand and supply of labour markets • naturally leads to an accounting system that includes values, volumes and prices. • In-line with the valuation of some SNA assets, such as natural capital.	• Assumes labour is paid according to its marginal productivity • sensitive to the choice of discount rate • sensitive to the rate of growth of income • relies upon accurate data on earnings, life tables and employment rates

Source: UNECE (2016)

In terms of producing a human capital satellite account for the UK, we propose to use the same methodology as the currently published UK human capital stock estimates, that is the life-time income approach. It should be noted that most academic studies into valuing human capital assets have taken the life-time income approach, as given in Table 3

.

Table 3: An overview of selected national studies applying income-based approach

Examples of national studies	Country	Motivation	Time range	Main data sources	Population covered	Market/Nonmarket activities
Jorgenson and Fraumeni (1989, 1992a, 1992b)	United States	New systems of national accounts, Output of education sector	1948-1984, 1947-1987	Rich data based on decades of research	Age 0-75	Both
Ahlroth, et al. (1997)	Sweden	Output of education sector	1967, 1973, 1980, 1990	Level of living surveys	Age 0-75	Both
Ervik, et al (2003)	Norway	Output of higher education sector	1995	Register data	Age 20-64	Market only
Wei (2004, 2008)	Australia	Incorporating human capital into the SNA (Stock/Flow)	1981-2001	Census data	Age 18 (25)- 65, labour force/whole population	Market only
Le, et al (2006)	New Zealand	Measuring human capital (Stock)	1981-2001	Census data	Age 18-64	Market only
Gu and Wong (2008)	Canada	Human capital contribution to national wealth account	1970-2007	Census /labour force survey	Age 15-74	Market only
Liu and Greaker (2009)	Norway	Measuring human capital (Stock)	2006	Register data	Age 15(16)- 67(74), labour force/ whole population	Market only
Christian (2010, 2012)	United States	Measuring human capital (Stock/Investment)	1994-2009	Rich data	Age 0-80	Both
Coremberg (2010)	Argentina	Measuring human capital (Stock)/Output of education sector	1997, 2001, 2004	Household permanent survey	Age 15-65	Market only
Li, et al. (2010)	China	Measuring human capital (Stock)	1985-2007	Household survey/Health and nutrition survey	Age 0-60 (55 for female)	Market only
Jones and Chiripanhura (2010)	United Kingdom	Measuring human capital (Stock)	2001-2009	Labour force survey	Age 16-64	Market only

Source: OECD (2012)

4.2 Theoretical consequences of incorporating human capital assets into the sequence of institutional sector accounts.

The incorporation of human capital into the sequence of institutional sector accounts, to explain the movement between two balance sheet positions within a satellite account, has to solve a number of questions for it to fit into a quadruple entry accounting framework, some of which are more straight forward than others. The following sections discuss these questions and proposes potential solutions which allows us to move forward with the conceptual construction of a satellite account without suggesting that these are the only possible solutions to the questions. Section 5 then discusses the evaluation of the conceptual human capital satellite account framework impacts based on published statistical data to produce for the UK an experimental human capital satellite account.

4.2.1 Production of human capital assets.

In this section we introduce and discuss the consequences of treating human capital as a produced asset. This uses the example of a Human Capital Satellite Account provided by Canada and given in UNECE (2016) as its starting point. As a produced asset we need to identify an output of a production function and its inputs. This output is then treated as gross fixed capital formation on human capital which is then an addition in the period to the opening human capital asset stock. This along with depreciation (consumption of fixed capital), revaluations and other volume changes provides the changes between the opening human capital asset stock and the closing human capital asset stock on the balance sheets. Before getting into the transaction discussion, we need to decide on which sector is producing the human capital assets. Current international guidance on human capital gives two options for the producing sector:

Option 1: to look upon the relevant activities in the sector paying for the produced services as producing a capital output, and subsequently transferring these outputs, via capital transfers, to the households; and

Option 2: to look upon the relevant activities in the sector paying for the produced services as producing a non-capital output that is transferred to the households where it is used as intermediate consumption into the production process of households producing their own human capital.

Our working assumption is that human capital is embedded in individuals and its production is done by the individuals in whom it is embedded. Option 2 characterises this position better than option 1, hence is preferred. This means that production of human capital assets takes place in the household sector using non-capital outputs transferred to them by those sectors paying for the relevant produced services.

The next question to face is what the non-capital outputs being used by the household sector to produce human capital assets are. Based on Mincer (1974) we can state that an individual's wage is a return to human capital, within which are two elements a return to education and the return to vocational experience. This implies that the production of human capital is a function of education and vocational experience, or we could expand it a little more and state that the production of human capital is a function of education, vocational training, and vocational experience. From this we surmise that the required inputs used by the household sector to produce human capital are

education, vocational training, and vocational experience. Two of these elements are already recorded within the national account framework, namely education services and expenditure on training, the valuation of the third work experience as an intermediate input into a production process is more problematic but can be seen as a reason why the cost-approach and life-time income approach do not achieve equality. The conceptual solve for this is to include as an intermediate input the opportunity cost of the work experience achieved, this would need to be quality adjusted as not all work experience is equal for giving a monetary return, however the SNA framework does not explicitly include opportunity costs within its structure, so the contribution of work experience to the net investment in human capital would be captured within the value-added component.

In terms of 'on-the-job training', the national accounts framework already includes purchased training within the intermediate consumption of the purchasing sector and would allow for its imputation as an intermediate input service for the household sector to receive as an input to human capital production. The same is true for paid for education this gets reclassified from household final consumption expenditure and included as intermediate consumption within the formation of human capital. The complexity in education arises within the government provided education funded via general taxation, as this is currently recorded within national accounts as a non-market output consumed as final consumption expenditure by the originating sector. If these non-market education services are going to be used by the household sector as an intermediate service in the production of human capital assets, then it requires the reclassification from non-market to market output, as within the national accounting framework non-market output can only be consumed by the producing sector[6]. Due to re-routing these transactions from the corporate, government and NPISH sectors to the household sector, to produce human capital, we must provide the funds to the household sector via the use of current transfers from the providing sector. This is done so that we do not distort the institutional sector's saving and net lending/borrowing estimates due to the re-routing of transactions.

From the above discussion we have identified, and where necessary reclassified, the cost elements used in the production of human capital, but we now need to express the value of the resulting human capital output. As mentioned above, the current ONS published human capital stock estimates use the life-time income approach to derive the values and likewise we follow this methodology to determine the value of human capital output which will be included as gross fixed capital formation within the household sector.

The basic equation for estimating the monetary value of human capital stocks from the life-time income approach is given by equation 1.[7]

$$HC = \sum_{age} \sum_{edu} LLI_{age}^{edu} \, N_{age}^{edu}) \tag{1}$$

[6] Conceptually this movement of education services from non-market to market would require an addition of a mark-up for net operating surplus to reflect it being now market output, or a different means of valuing education services (Corrado *et al.* (2020) could provide such a valuation method). While acknowledging this deficiency, we don't attempt to estimate the required mark-up or adjust the valuation of the output of education to reflect this in this paper.

[7] Unless otherwise stated the basic equations used in this paper come from UNECE (2016).

Where:

HC = monetary value of the stock of human capital

LLI_{age}^{edu}= present value of life-time labour income for a representative individual in the corresponding age and educational attainment category

N_{age}^{edu} = number of individuals in the corresponding age and educational attainment category

This equation defines the monetary value of the stock of human capital and can be applied separately to males and females to estimate the stock of human capital. For the purposes of constructing the human capital satellite account we are more interested in the flows between two accounting periods and therefore it is the change in human capital asset stocks and its decomposition which is of interest. The change in human capital assets can be defined as shown in equation 2:

$$HC^t - HC^{t-1} = \sum_{s,e,a} h_{s,e,a}^t N_{s,e,a}^t - \sum_{s,e,a} h_{s,e,a}^{t-1} N_{s,e,a}^{t-1}$$

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

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

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

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

(2)

Where:

HC= *national human capital asset stock*

h= *human capital per capita or life-time income*

N= *number of individuals*

sur= *survival rate*

s, e, a= *gender, education attainment and age characteristics*

In Equation 2, the first term in the latter equality represents the gross investment in human capital that occurred and therefore this term is also equal to the in-period human capital output within the household sector, the second term is the depreciation (therefore the first term minus the second term gives net investment) and the last term is revaluations. The other element which we need to consider in the production of human capital assets is changes due to other volume changes. Other volume changes are non-transaction or price-based changes and in the case of the life-time income

approach to measuring human capital other volume changes would include changes to the model assumptions such as the Section 4.2.3 below.

In terms of the national accounting framework, the output of human capital assets would be designated as output for own consumption (P.12) rather than market output (P.11) due to the household sector producing it and using it in the form of gross fixed capital formation (P.51g).

Conceptually, it is worth mentioning, that the life-time income approach would need to capture the individuals in formal education (which in the UK are those pupils < 16 years of age) otherwise you would be capturing intermediate costs associated with individuals not in the gross investment term, if for instance you just estimated the human capital for the working population or working age population. A possible solve for this is to calculate life-time incomes for the < 16 years of age population in a similar manner to that suggested in Corrado *et al.* (2020).

Bucknall et al. (2021) raised the issue of whether the addition to human capital of those in full-time education should be recorded as gross fixed capital formation or work-in-progress within the national accounting framework, given that they are not participating in production and therefore would not meet the definition of an asset. The formal SNA definition of the asset boundary is:

"…fixed assets consists of goods and services that are used in production for more than one year."

United Nations et al. (2009); p.198.

However, in the above discussion we have stated that the need to include those in full-time education (< 16 years of age) within the estimate of the gross investment in human capital to avoid an issue with education being used as an input to human capital formation. The rationale for being able to do this within the accounting framework is given by the following:

"In general, incomplete construction projects and immature animals and plantations are treated as work-in-progress. They are reclassified from inventories to fixed capital when complete and delivered to the unit intending to use them as fixed assets. However, ***when assets are being produced on own account, the partially complete products are recorded as fixed capital formation as work takes place.****"*

United Nations *et al. (2009); p201. (Emphasis added)*

This means by treating the human capital output as output for own consumption, we can treat what is conceptually an incomplete human capital asset as fixed capital formation as it occurs, thereby solving any difficulty here.

This then completes our discussion on the recording of human capital production and gross fixed capital formation within the national accounting framework of a satellite account. We now turn to the consequences of having human capital assets and what that means for the employer -employee relationship.

4.2.2 Rental of human capital assets

In the above section, we discussed how the human capital asset is formed and economic ownership is with the household sector due to its embedded nature in individuals. As a fixed asset we want the return to asset to appear as net operating surplus which means adjusting the relationship between labour and human capital, and the related compensation of employees and human capital services, to achieve this within the satellite account structure. While this can be solved, by doing so it raises a fundamental paradigm shift from the current framework. Exploring this paradigm shift within a satellite account structure is fine but it could raise issues for finally incorporating human capital assets within the core national accounts framework.

Currently, a household institutional unit which is employed receives a compensation of employees from the employer and this includes wages and salaries in cash and kind (D.11) and social insurance contributions payable by employers (D.12). Economically speaking the unit of labour is homogenous and one unit of labour is as good as the next unit of labour. However, by introducing human capital assets we must consider the distinction between labour and human capital to avoid double-counting within an accounting framework and to have the return to a produced asset in the correct place. It also raises the question of whether in a modern economy a household unit is providing labour or a human capital service? The practical outcome is that either all or a fraction of current compensation of employees needs to be re-allocated to operating surplus within the generation of income account. For the purposes of the first experimental human capital satellite account, we intend to take the position that all of compensation of employees will be associated as income to the human capital asset. This means that the household sector will have an output associated with providing human capital services to employers, which will also appear in the intermediate consumption of the employer (thereby being GVA neutral) and then once taxes less subsidies on production have been considered the remaining GVA will be attributable to operating surplus and we have the return to capital in the correct location. Conceptually, it also means that the life-time income used to calculate human capital needs to be in alignment with current period compensation of employees (thereby covering the full employment cost) and under the assumption that all current compensation of employees is attributable as income to human capital then the distinction between mixed income (B.3g) and operating surplus (B.2g) disappears; as what is currently recorded as mixed income (through not being able to split self-employed compensation of employees from the self-employed return to capital) becomes solely a return to self-employed capital either physical traditional assets or human capital.

The remaining question for the accounting framework is what type of market output the households is providing to employers through the provision of human capital services. This can be answered from looking at how traditional assets economically owned by one institutional unit is made available for use by another institutional unit without a change in economic ownership within the national accounting framework; the answer to this is as an operating lease. Under an operating lease, the lessor (employee) has a productive activity that involves the produced asset (human capital) in question and is responsible for the production risks associated with the operational status of the asset. Payments by the lessee (employer) are treated as payments for a service (the previous compensation of employees). In effect, the employer is making rental payments to access the human capital economically owned by the household, with the rental payments appearing in the intermediate consumption of the lessee. So, this is the underlying paradigm shift from the incorporation of human capital assets within the national accounting framework, households stop providing a labour input, by definition, and start providing a rental of human capital services.

Further, as human capital assets have characteristics which a labour input does not explicitly have, it means human capital asset characteristics could be included within the production functions used within the input-output framework. i.e., medical services would require the input of '*x*' amount of medically qualified human capital rather than '*x'* amount of labour input. Which could have benefits for understanding distributional elements within the accounts. This, however, is a complexity which would require more thought and availability of data to realise and therefore is something to consider as part of a long-term research project, but it does highlight the potential analytical benefits of having human capital within the accounting framework.

This section has discussed the underlying paradigm shift (from labour input to provider of human capital services) which is a consequence of incorporating human capital into the national accounting framework and how it is a necessary shift to enable the return to human capital to appear within the correct balancing item (operating surplus) without creating double-counting. The next section considers the implications within the accounting framework of immigration and emigration and how this would conceptually be an 'other volume 'change (sector re-classification of an asset).

4.2.3 Immigration and emigration as other volume changes and revaluations

The purpose of the human capital satellite account is to provide a rationale for the change in human capital balance sheet position between two accounting periods, through the decomposition of the change in human capital stock into transactions (gross investment in human capital and consumption of fixed capital), other volume changes and revaluations. In the discussion in sections 4.2.1 and 4.2.2 we focused on conceptually determining the human capital gross investment and the human capital asset production, though in the explanation of equation 2 we gave the algebra for the determination of consumption of fixed capital (P.51c) and revaluations. This section considers the source of two other volume changes, immigration and emigration. These are especially considered to conceptually address an issue of how to record these flows which were raised by Bucknall *et al.* (2021). Implementing these changes to be conceptually correct could prove difficult due to data availability but it is worth discussing the implications so that a fuller understanding can be given for one of the caveats to the experimental estimates produced later in the paper.

When a non-resident individual moves to the domestic economy of concern, we have a movement also of embedded human capital with that individual. A possible way of treating this is to see immigration as a balance sheet transfer due to economic ownership of the asset not changing and therefore no transaction should be recorded. The balance sheet transfer should be recorded in the other volume changes account as a K.61 Changes in sector classification and institutional unit structure, as the sector classification of the human capital asset has changed from S.2 to S.14, and results in the balance sheet stock of human capital increasing.

This addition of human capital stock caused by immigration would feature as an additional argument within equations given in Equation 2. This alteration in the life-time income equation is given below, see equation 3.

$$HC^t - HC^{t-1} = \sum_{s,e,a} h^t_{s,e,a} N^t_{s,e,a} - \sum_{s,e,a} h^{t-1}_{s,e,a} N^{t-1}_{s,e,a}$$

$$= \sum_{s,e,a\notin\{Imm\}} h^t_{s,e,a} N^t_{s,e,a} - \sum_{s,e,a\notin\{Imm\}} h^t_{s,e,a} N^{t-1}_{s,e,a} + \sum_{s,e,a\notin\{Imm\}} \left(h^t_{s,e,a} - h^{t-1}_{s,e,a}\right) N^{t-1}_{s,e,a} + \sum_{s,e,a\in\{Imm\}} h^t_{s,e,a} N^t_{s,e,a}$$

$$= \left(\sum_{s,e,a\notin\{Imm\}} h^t_{s,e,a} N^t_{s,e,a} - \sum_{s,e,a\notin\{Imm\}} h^t_{s,e,a+1} sur^{t-1}_{a,a+1} N^{t-1}_{s,e,a} \right)$$

$$- \left(\sum_{s,e,a\notin\{Imm\}} h^t_{s,e,a} N^{t-1}_{s,e,a} - \sum_{s,e,a\notin\{Imm\}} h^t_{s,e,a+1} sur^{t-1}_{a,a+1} N^{t-1}_{s,e,a} \right)$$

$$+ \sum_{s,e,a\notin\{Imm\}} \left(h^t_{s,e,a} - h^{t-1}_{s,e,a}\right) N^{t-1}_{s,e,a} + \sum_{s,e,a\in\{Imm\}} h^t_{s,e,a} N^t_{s,e,a}$$

(3)

The first term given in the latter equality in equation 3 represents the gross investment in human capital from non-immigrants, the second term represents the amount of in period depreciation of the non-immigrant human capital asset, the third term is the revaluation of the non-immigrant human capital stock between the two periods and the last term represents the transfer of the human capital asset caused by the immigration.

In a similar manner to immigration, emigration can be seen as a transfer of human capital assets between the household sector (S.14) and the household sector in the destination country. Again, as economic ownership of the human capital asset is not changing, a transaction cannot be recorded within the sequence of accounts, therefore it is treated as a change in other volumes. The relevant other flow is K.61 Changes in sector classification and institutional unit structure. This early disposal of a human capital asset is part of the depreciation term in Equation 2 above. Once again, we can decompose the depreciation (consumption of fixed capital) term into its component elements. UNECE (2016) provides a decomposition of depreciation into changes in lifetime incomes due to ageing of the population and individuals quitting the population because of retirement, death or emigration, shown in equation 4:

$$\left(\sum_{s,e,a} h^t_{s,e,a} N^{t-1}_{s,e,a} - \sum_{s,e,a} h^t_{s,e,a+1} sur^{t-1}_{a,a+1} N^{t-1}_{s,e,a} \right) = \sum_{s,e,a} \left(h^t_{s,e,a} - h^t_{s,e,a+1}\right) sur^{t-1}_{a,a+1} N^{t-1}_{s,e,a} + \sum_{s,e,a} h^t_{s,e,a} \left(N^{t-1}_{s,e,a} - sur^{t-1}_{a-1,a} N^{t-1}_{s,e,a-1}\right)$$

(4)

While UNECE (2016) essentially treats emigration as an early disposal the same as death, this does not reflect the proposal above where we suggest that it is best treated as an 'other flow' (K.61). Therefore, because we would like to treat it as an 'other flow', as a mirror to immigration, we feel

this change in working population should be treated outside of the depreciation component, as it does not reflect something which is related to its employment in a production process. The inclusion of "death" in the depreciation component remains valid, as it is analogous to "normal damage and loss" of other produced non-financial assets which is also included in the depreciation component. Anything above the "normal" rate should in turn be treated as an 'other flow' but under catastrophic losses (K.3). This suggests that to incorporate emigration into the change in stocks of human capital we should include an additional term in Equation 2; see equation 5.

$$
\begin{aligned}
HC^t - HC^{t-1} &= \sum_{s,e,a} h^t_{s,e,a}\, N^t_{s,e,a} - \sum_{s,e,a} h^{t-1}_{s,e,a} N^{t-1}_{s,e,a} \\
&= \sum_{s,e,a\notin\{Imm,Em\}} h^t_{s,e,a}\, N^t_{s,e,a} \\
&\quad - \sum_{s,e,a\notin\{Imm,Em\}} h^t_{s,e,a} N^{t-1}_{s,e,a} \\
&\quad + \sum_{s,e,a\notin\{Imm,Em\}} \left(h^t_{s,e,a} - h^{t-1}_{s,e,a}\right) N^{t-1}_{s,e,a} \\
&\quad + \sum_{s,e,a\in\{Imm,Em\}} h^t_{s,e,a} N^t_{s,e,a} \\
&= \left(\sum_{s,e,a\notin\{Imm,Em\}} h^t_{s,e,a}\, N^t_{s,e,a} - \sum_{s,e,a\notin\{Imm,Em\}} h^t_{s,e,a+1} sur^{t-1}_{a,a+1} N^{t-1}_{s,e,a} \right) \\
&\quad - \left(\sum_{s,e,a\notin\{Imm,Em\}} h^t_{s,e,a} N^{t-1}_{s,e,a} - \sum_{s,e,a\notin\{Imm,Em\}} h^t_{s,e,a+1} sur^{t-1}_{a,a+1} N^{t-1}_{s,e,a} \right) \\
&\quad + \sum_{s,e,a\notin\{Imm,Em\}} \left(h^t_{s,e,a} - h^{t-1}_{s,e,a}\right) N^{t-1}_{s,e,a} + \sum_{s,e,a\in\{Imm\}} h^t_{s,e,a} N^t_{s,e,a} - \sum_{s,e,a\in\{Em\}} h^t_{s,e,a} N^t_{s,e,a}
\end{aligned}
\tag{5}
$$

The last term in equation 5 would then represent the deduction in human capital assets from the stock level caused by the removal from the working population of those emigrating. This means that the decomposition of the depreciation component would only deal with those not emigrating, equation 6 below.

$$
\sum_{s,e,a\notin\{Em\}} \left(h^t_{s,e,a} - h^t_{s,e,a+1}\right) sur^{t-1}_{a,a+1} N^{t-1}_{s,e,a} + \sum_{s,e,a\notin\{Em\}} h^t_{s,e,a} \left(N^{t-1}_{s,e,a} - sur^{t-1}_{a-1,a} N^{t-1}_{s,e,a-1}\right)
\tag{6}
$$

Further, to be conceptually correct the movement of individuals between economically active and non-economically active prior to retirement, i.e. moving into the informal household sector to provide childcare, would also need to be reflected in the "other volume" changes in the same

manner as for emigration and the return to being economically active would be similar to immigration. Future research which expanded the production boundary to include the informal household sector would mitigate having to make this adjustment for the movement between economically active and non-economically active.

The above discussions have conceptually explained how human capital can be incorporated into the sequence of accounts and how certain issues can be resolved to achieve this aim, though we acknowledge further research is required on many of these points. The next section sets up the conceptual impacts of including human capital assets into a supply and use framework and the sequence of institutional sector accounts for a experimental satellite account and then we look to provide some early experimental estimates and impacts for these changes using UK published estimates. These early experimental impacts are caveated based on the conceptual discussions, Section 4 above, to show the challenges of producing an integrated human capital satellite account and the need for further research in this and related areas.

5 Human Capital Satellite Account: Initial estimates and current data challenges

This section provides the conceptual changes which would occur through adapting the current UK supply and use tables and sequence of institutional sector accounts to include human capital assets for inclusion in a UK human capital satellite account. We then consider the availability of published UK data to evaluate these conceptual changes to provide some early estimates of the impact of human capital on a selection of balancing items, including gross value added. These early experimental estimates come with some caveats to the accuracy of these estimates but they provide a starting point for future research which would look to refine and develop these first experimental estimates for the UK.

The next section discusses the conceptual changes, Section 5.2 considers the available published data we can use to evaluate these changes, Section 5.3 provides a tabular presentation of the changes for one year (2018) and finally Section 5.4 provides some time series analysis for a number of main aggregates in comparison with current estimates, along with a general discussion of the experimental estimates.

5.1 Conceptual changes to supply and use tables and sequence of institutional sector accounts.

The discussion in Section 4 above leads to the calculation of the theoretical impacts on the sequence of economic accounts, specifically on the main balancing items of gross value added, gross operating surplus, gross national income, net trade, net saving and net lending/borrowing from the introduction of human capital assets. Table 4 gives the revisions to a supply table for the incorporation of human capital assets, Table 5 gives the revisions to a use table for the incorporation of human capital assets and Table 6 gives the revisions to the institutional sector accounts from incorporation of human capital assets. As illustrated in Table 6, the theoretical exposition of the changes required following the introduction of human capital assets leads to the expected final impact in the sequence of non-financial accounts on net leading/borrowing being zero. This is due to there being no new financing of transactions which need to be recorded in the financial account.

The abbreviations used in Table 4, Table 5 and Table 6 are:

$E^G(D)$ =	Direct government expenditure on education
$E^N(D)$ =	Direct NPISH expenditure on education
$E^H(D)$ =	Direct Household expenditure on education
OJT^C =	Total job-related training costs - corporations
OJT^G =	Total job-related training costs - government
OJT^N =	Total job-related training costs - NPISH
MHC^C =	Intermediate inputs for Human Capital produced in the corporations sector
MHC^G =	Intermediate inputs for Human Capital produced in the government sector
MHC^N =	intermediate inputs for human capital produced in the NPISH sector
HC_D^{LT} =	Human capital gross investment (life-time income approach) – domestic production
$HC_{Im}^{LT} = \sum_{s,e,a \in \{Imm\}} h_{s,e,a}^t N_{s,e,a}^t$ =	Addition to Human capital asset stocks (life-time income approach) – Immigration
$HC_{Em}^{LT} = \sum_{s,e,a \in \{Em\}} h_{s,e,a}^t N_{s,e,a}^t$ =	Deduction from human capital asset stocks (life-time income approach) - Emigration
HCS_H^i =	Payments to households for accessing human capital by sector *i*.
HCS_M^i=	Imports: payments to non-resident household for accessing human capital by sector i.
HCS^X =	Exports: Payments to resident households to access human capital services from rest of world.
$P.51c^{HC}$ =	Consumption of fixed capital on human capital assets (depreciation)
$\sum_{s,e,a}\left(h_{s,e,a}^t - h_{s,e,a}^{t-1}\right) N_{s,e,a}^{t-1} =$	Nominal revaluations, where $h_{s,e,a}^t$ is life-time income per capita for a given gender, educational attainment and age; $N_{s,e,a}^{t-1}$ is the working population for a given gender, educational attainment and age from the previous period[8].

[8] Section 4.2.1 considers nominal revaluations and how it fits into the change in human capital stock levels between two accounting periods.

Table 4: Revisions to the Supply Table from the introduction of Human capital assets

		Producing Sector				Imports	Total Supply
Transaction	**Product**	**Corporations**	**Government**	**NPISH**	**Households**	**RoW**	
P.11	**Human capital intermediate input services**	$+MHC^C$ (= OJT^C)	$+MHC^G$ (=OJT^G + $E^G(D)$)	$+ MHC^N$ (OJT^N + $E^N(D)$)			$+MHC^C$ $+MHC^G$ $+ MHC^N$
	Human capital rental services				$+HCS^H$ (=$+HCS_H^C$ $+HCS_H^G$ $+HCS_H^N$ + $+HCS^X$)	$+HCS^M$ (=HCS_M^C + HCS_M^C + HCS_M^N)	$+HCS^H$ $+HCS^M$
P.12	**Human capital investment**				$+HC_D^{LT}$		$+HC_D^{LT}$
P.13	**Non-market output**		$-OJT^G$ $-E^G(D)$	$-OJT^N$ $-E^N(D)$			$-OJT^G$ $-E^G(D)$ $-OJT^N$ $-E^N(D)$
	Total output	$+MHC^C$	0	0	$+HC_D^{LT}$ $+HCS^H$		

Table 5: Revisions to the Use Table from the introduction of human capital assets

		Consuming Sector				P.3			GFCF	Exports	Total Use
Transaction	**Product**	**Corporations**	**Government**	**NPISH**	**Households**	**Government**	**NPISH**	**Households**	**Households**	**RoW**	
P.2	**Human capital intermediate input services**	0	0	0	$+E^H(D)$ $+MHC^C$ $+MHC^G$ $+MHC^N$	0	0	$-E^H(D)$	0	0	$+MHC^C$ $+MHC^G$ $+MHC^N$
	Human capital investment	0	0	0	0	0	0	0	$+HC_D^{LT}$		$+HC_D^{LT}$
	Human capital rental services	$+HCS_H^C$ $+HCS_M^C$	$+HCS_H^G$ $+HCS_M^G$	$+HCS_H^N$ $+HCS_M^N$	0	0	0	0	0	$+HCS^X$	$+HCS^H$ $+HCS^M$
P.13	**Non-market output**	0	0	0	0	$-OJT^N$ $-E^N(D)$	$-OJT^N$ $-E^N(D)$	0	0	0	$-OJT^N$ $-E^N(D)$ $-OJT^N$ $-E^N(D)$
	Total intermediate consumption	$+HCS_H^C$ $+HCS_M^C$	$+HCS_H^G$ $+HCS_M^G$	$+HCS_H^N$ $+HCS_M^N$	$+E^H(D)$ $+MHC^C$ $+MHC^G$ $+MHC^N$						
	Gross Value Added	$+MHC^C$ $-HCS_H^C$ $-HCS_M^C$	$-HCS_H^G$ $-HCS_M^G$	$-HCS_H^N$ $-HCS_M^N$	$+HC_D^{LT}$ $+HCS^H$ $-E^H(D)$ $-MHC^C$ $-MHC^G$ $-MHC^N$						
	D.1	$-HCS_H^C$ $-HCS_M^C$	$-HCS_H^G$ $-HCS_M^G$	$-HCS_H^N$ $-HCS_M^N$							
	D.2 less D.3	0	0	0							
	B.2g	$+MHC^C$	0	0	$+HC_D^{LT}$ $+HCS^H$ $-E^H(D)$ $-MHC^C$ $-MHC^G$ $-MHC^N$						
	Total output	$+MHC^C$	0	0	$+HC_D^{LT}$ $+HCS^H$						

Table 6 Revisions to the institutional sector accounts from introducing Human Capital Assets

Use					Production Account	Resource				
Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy
					Domestic Output					
					Market output	$+HCS^{H}$	$+MHC^{N}$ (OJT^{N} + $E^{N}(D)$)	$+MHC^{G}$ (=OJT^{G} + $E^{G}(D)$)	$+MHC^{C}$ (= OJT^{C})	$+HCS^{H}$ $+MHC^{N}$ $+MHC^{G}$ $+MHC^{C}$
					Output for own consumption	$+HC_{D}^{LT}$				$+HC_{D}^{LT}$
					Non-market output		$-OJT^{N}$ $-E^{N}(D)$	$-OJT^{G}$ $-E^{G}(D)$		$-OJT^{N}$ $-E^{N}(D)$ $-OJT^{G}$ $-E^{G}(D)$
	$+HCS_{H}^{C}$ $+HCS_{M}^{C}$	$+HCS_{H}^{G}$ $+HCS_{M}^{G}$	$+HCS_{H}^{N}$ $+HCS_{M}^{N}$	$+E^{H}(D)$ $+MHC^{C}$ $+MHC^{G}$ $+MHC^{N}$	Intermediate Consumption					
$+MHC^{C}$ $+HCS^{X}$ $-HCS^{M}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$	$+MHC^{C}$ $-HCS_{H}^{C}$ $-HCS_{M}^{C}$	$-HCS_{H}^{G}$ $-HCS_{M}^{G}$	$-HCS_{H}^{N}$ $-HCS_{M}^{N}$	$+HCS^{H}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$	Gross Value Added					
$+MHC^{C}$ $+HCS^{X}$ $-HCS^{M}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$ $-P.51c^{HC}$	$+MHC^{C}$ $-HCS_{H}^{C}$ $-HCS_{M}^{C}$	$-HCS_{H}^{G}$ $-HCS_{M}^{G}$	$-HCS_{H}^{N}$ $-HCS_{M}^{N}$	$+HCS^{H}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$ $-P.51c^{HC}$	Net Value Added					

Use					Generation of Income Account	Resource				
Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy
					Gross Value added	$+HCS^{H}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$	$--HCS_{H}^{G}$ $-HCS_{M}^{G}$	$-HCS_{H}^{N}$ $-HCS_{M}^{N}$	$+MHC^{C}$ $-HCS_{H}^{C}$ $-HCS_{M}^{C}$	$+MHC^{C}$ $+HCS^{X}$ $-HCS^{M}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$
					Net Value added	$+HCS^{H}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$ $-P.51c^{HC}$	$-HCS_{H}^{G}$ $-HCS_{M}^{G}$	$-HCS_{H}^{N}$ $-HCS_{M}^{N}$	$+MHC^{C}$ $-HCS_{H}^{C}$ $-HCS_{M}^{C}$	$+MHC^{C}$ $+HCS^{X}$ $-HCS^{M}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$ $-P.51c^{HC}$
$-HCS_{H}^{C}$ $-HCS_{M}^{C}$ $-HCS_{H}^{C}$ $-HCS_{M}^{C}$ $-HCS_{H}^{N}$ $-HCS_{M}^{N}$	$-HCS_{H}^{C}$ $-HCS_{M}^{C}$	$-HCS_{H}^{G}$ $-HCS_{M}^{G}$	$-HCS_{H}^{N}$ $-HCS_{M}^{N}$		Compensation of Employees					
					Taxes less subsidies on production					
$+MHC^{C}$ $+HCS^{X}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$	$+MHC^{C}$	0	0	$+HCS^{H}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$	Gross Operating Surplus					
$+MHC^{C}$ $+HCS^{X}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$ $-P.51c^{HC}$	$+MHC^{C}$	0	0	$+HCS^{H}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$ $-P.51c^{HC}$	Net Operating Surplus					

Use						Allocation of primary income Account	Resource					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
						Gross Operating Surplus	$+HCS^{H}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$	0	0	$+MHC^{C}$	$+MHC^{C}$ $+HCS^{X}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$	
						Net Operating Surplus	$+HCS^{H}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$ $-P.51c^{HC}$	0	0	$+MHC^{C}$	$+MHC^{C}$ $+HCS^{X}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$ $-P.51c^{HC}$	
$-HCS^{X}$						Compensation of Employees	$-HCS^{H}$	0	0	0	$-HCS^{H}$	$-HCS^{M}$
						Property income						
$-HCS^{X}$	$+MHC^{C}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$	$+MHC^{C}$			$+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$	Balance of primary incomes, gross						
$-HCS^{X}$	$+MHC^{C}$ $+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$	$+MHC^{C}$			$+HC_{D}^{LT}$ $-E^{H}(D)$ $-MHC^{C}$ $-MHC^{G}$ $-MHC^{N}$ $-P.51c^{HC}$	Balance of primary income, net						

Use						Secondary distribution of income Account	Resource					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
						Balance of Primary incomes, gross	$+HC_D^{LT}$ $-E^H(D)$ $-MHC^C$ $-MHC^G$ $-MHC^N$	0	0	$+MHC^C$	$+MHC^C$ $+HC_D^{LT}$ $-E^H(D)$ $-MHC^C$ $-MHC^G$ $-MHC^N$	
						Balance of primary incomes, net	$+HC_D^{LT}$ $-E^H(D)$ $-MHC^C$ $-MHC^G$ $-MHC^N$ $-P.51c^{HC}$	0	0	$+MHC^C$	$+MHC^C$ $+HC_D^{LT}$ $-E^H(D)$ $-MHC^C$ $-MHC^G$ $-MHC^N$	
		$+MHC^C$	$+MHC^G$	$+MHC^N$		Current Transfers	$+MHC^C$ $+MHC^G$ $+MHC^N$	0	0	0		
	$+HC_D^{LT}$ $-E^H(D)$ $-MHC^G$ $-MHC^N$	0	$-MHC^G$	$-MHC^N$	$+HC_D^{LT}$ $-E^H(D)$	Disposable income, gross						
	$+HC_D^{LT}$ $-E^H(D)$ $-MHC^G$ $-MHC^N$ $-P.51c^{HC}$		$-MHC^G$	$-MHC^N$	$+HC_D^{LT}$ $-E^H(D)$ $-P.51c^{HC}$	Disposable income, net						

Use						Use of income Account	Resource					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
						Disposable income, gross	$+HC_D^{LT}$ $+-E^H(D)$	$-MHC^N$	$-MHC^G$		$+HC_D^{LT}$ $-E^H(D)$ $-MHC^G$ $-MHC^N$	
						Disposable income, net	$+HC_D^{LT}$ $-E^H(D)$ $-P.51c^{HC}$		$-MHC^N$		$+HC_D^{LT}$ $-E^H(D)$ $-MHC^G$ $-MHC^N$ $-P.51c^{HC}$	
	$-OJT^N$ $-E^N(D)$ $-OJT^N$ $-E^N(D)$ $-E^H(D)$		$-OJT^N$ $-E^N(D)$	$-OJT^N$ $-E^N(D)$	$-E^H(D)$	Final consumption expenditure		0	0	0		
	$+HC_D^{LT}$		0	0	$+HC_D^{LT}$	Saving, gross						
	$+HC_D^{LT}$ $-P.51c^{HC}$				$+HC_D^{LT}$ $-P.51c^{HC}$	Saving, net						

Changes in Assets						Changes in net worth due to saving and capital transfers	Changes in liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
						Saving, net	$+HC_D^{LT}$ $-P.51c^{HC}$				$+HC_D^{LT}$ $-P.51c^{HC}$	
						Capital transfers		0	0	0		+
	$+HC_D^{LT}$ $-P.51c^{HC}$				$+HC_D^{LT}$ $-P.51c^{HC}$	Changes in net worth due to saving and capital transfers						

Changes in Assets						Acquisition of non-financial assets account	Changes in liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
						Changes in net worth due to saving and capital transfers	$+HC_D^{LT}$ $-P.51c^{HC}$				$+HC_D^{LT}$ $+HC_M^{LT}$ $-HC_X^{LT}$ $-P.51c^{HC}$	
	$+HC_D^{LT}$				$+HC_D^{LT}$	Gross Fixed Capital formation		0	0	0		
	$-P.51c^{HC}$				$-P.51c^{HC}$	Consumption of fixed capital						
	0				0	Net lending/net borrowing						

Assets						Opening Balance sheet	Liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
	$+HCA_{t-1}^{LT}$				$+HCA_{t-1}^{LT}$	Human Capital						
						Net worth	$+HCA_{t-1}^{LT}$	0	0	0	$+HCA_{t-1}^{LT}$	

Changes in Assets						Changes in net worth due to saving and capital transfers	Changes in liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
	$+HC_D^{LT}$ $-P.51c^{HC}$				$+HC_D^{LT}$ $-P.51c^{HC}$	Human Capital						
						Changes in net worth due to saving and capital transfers	$+HC_D^{LT}$ $-P.51c^{HC}$	0	0	0	$+HC_D^{LT}$ $-P.51c^{HC}$	

Changes in Assets						Changes in net worth due to other changes in volume of assets	Changes in liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
	$+HC_{Im}^{LT}$ $-HC_{Em}^{LT}$				$+HC_{Im}^{LT}$ $-HC_{Em}^{LT}$	Human Capital						
						Changes in net worth due to other changes in volume of assets	$+HC_{Im}^{LT}$ $-HC_{Em}^{LT}$				$+HC_{Im}^{LT}$ $-HC_{Em}^{LT}$	

Changes in Assets						Changes in net worth due to nominal holding gains and losses	Changes in liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
	$\sum_{s,e,a}(h_{s,e,a}^{t} - h_{s,e,a}^{t-1})N_{s,e,a}^{t-1}$				$\sum_{s,e,a}(h_{s,e,a}^{t} - h_{s,e,a}^{t-1})N_{s,e,a}^{t-1}$	Human Capital						
						Changes in net worth due to nominal holding gains and losses	$\sum_{s,e,a}(h_{s,e,a}^{t} - h_{s,e,a}^{t-1})N_{s,e,a}^{t-1}$	0	0	0	$\sum_{s,e,a}(h_{s,e,a}^{t} - h_{s,e,a}^{t-1})N_{s,e,a}^{t-1}$	

Assets						Closing Balance sheet	Liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
	$+HC_D^{LT}$ $-P.51c^{HC}+HC_{Im}^{LT}$ $-HC_{Em}^{LT}+\sum_{s,e,a}(h_{s,e,a}^{t} - h_{s,e,a}^{t-1})N_{s,e,a}^{t-1}$ $=+HCA_t^{LT}$				$+HC_D^{LT}$ $-P.51c^{HC}+HC_{Im}^{LT}$ $-HC_{Em}^{LT}+\sum_{s,e,a}(h_{s,e,a}^{t} - h_{s,e,a}^{t-1})N_{s,e,a}^{t-1}$ $=+HCA_t^{LT}$	Human Capital						
						Net worth	$+HCA_t^{LT}$	0	0	0	$+HCA_t^{LT}$	

The above theoretical sequence of accounts shows how the evolution of human capital assets between to balance sheet positions, and therefore the impact on net worth, is composed of the net investment in human capital, other volume changes (in theoretical case above immigration and emigration) and revaluations caused by the change in life-time incomes per capita between the two periods. Further, the use of current transfers from the corporation, government and NPISH sectors to the household sector negates any impacts on gross saving outside of the household sector and leaves the household net lending/borrowing (B.9) position unchanged, as expected due to there being no new financing in the system.

The next section considers how the currently published estimates can be used to evaluate the above theoretical impacts to produce the first experimental estimates for a human satellite account. We acknowledge that this means that some of the elements required are missing or conceptually incorrect, but this work still has value in demonstrating the significance of human capital assets on the main economic aggregates of interest; even if the accuracy of the estimates requires improvement. Future research could resolve some of the conceptual difficulties by producing a human capital model more suited to the human capital satellite account requirements, given current data source availability.

5.2 UK published data available to evaluate changes caused by incorporating human capital asset into a national account framework

This section discusses the published data available for evaluating the theoretical impacts given in the previous section. In the following briefly outline the data source and how well it meets the conceptual elements discussed above.

5.2.1 Data sources for education and training

The international guidance on determining the costs associated with education and training are given in the UNECE Satellite Account for Education and Training: Compilation Guide; UNECE (2020)[9].

This suggests constructing supply and use estimates for education and training with an education and training purpose breakdown. The Education and training purpose breakdown as recommended is as follows:

- EP0 - pre-primary education[10]
- EP1 - Primary education
- EP2- Secondary education
- EP3 - Higher education
- EP4 - Cultural, sport and recreation education
- EP5 - other education and vocational training
- EP6 - In-house training

[9] Available at: https://unece.org/satellite-account-education-and-training-compilation-guide-0#:~:text=The%20Compilation%20Guide%2C%20developed%20by%20the%20UNECE%20Task,publication%20%22Education%20at%20a%20Glance%22%20and%20the%20

[10] To align with UK reporting of government expenditure by COFOG, EP0 and EP1 are added together

- Associated products and administrative expenditures, not allocated

As a first step in producing an experimental Human Satellite Account, we have constructed the SAET supply and use tables for 2018 based on government expenditure data by COFOG, data extracted from the UK supply and use tables for 2018 (2020 edition) and the UK pilot compilation of Satellite Account for Education and Training 2014 (as given in UNECE(2020) Annex 7.2), the latter has been used to provide structural information on EP0-EP6 for estimates from the supply and use tables which lacked that breakdown.

Table 7: Satellite Account for Education and Training Supply Table, reference year 2018

		Education and training supply – 2018 (£m)							
		General Government	Central Government	Local Government	NPISH	Market producers of education services	imports	Taxes less subsidies on products	Total
Education and training purpose	EP0 - pre-primary education & EP1 - Primary education	26,233	762	25,471		8,166			60,632
	EP2- Secondary education	33,051	2,3723	9,328	8,620	1,868			76,590
	EP3 - Higher education	2,122	439	1,683	19,601	21,867	831		46,543
	EP4 - Cultural, sport and recreation education				270	1,671			1,941
	EP5 - other education and vocational training	5,149	1,220	3,929		13,013		922	24,233
	EP6 - In-house training					0			0
	Associated products and administrative expenditures, not allocated	3,489	2,120	1,369		0			6,978
Total output = Total current expenditure		70,044	28,264	41,780	28,491	46,585	831	922	216,917

Table 8: Satellite Account for Education and Training Use Table, reference year 2018

Use of Education and Training – 2018 (£m)

		General Government	Central Government	Local Government	NPISH	Households	Intermediate consumption market producers	Exports	Total
Education and training purpose	EP0 - pre-primary education & EP1 - Primary education	26,233	762	25,471		8,166			60,632
	EP2- Secondary education	33,051	23,723	9,328	7,317	1,868			76,590
	EP3 - Higher education	2,122	439	1,683	16,639	13,066	530	9,102	46,543
	EP4 - Cultural, sport and recreation education				230	1,671			1,941
	EP5 - other education and vocational training	5,149	1,220	3,929		1,206	12,729		24,233
	EP6 - In-house training								0
	Associated products and administrative expenditures, not allocated	3,489	2,120	1,369					6,978
TOTAL USE (INTERMEDIATE OR FINAL CONSUMPTION) = TOTAL CURRENT EXPENDITURE		70,044	28,264	41,780	24,186	25,977	13,259	9,102	216,917

5.2.2 Data sources for Human Capital Stock estimates.

The Office for National Statistics published the first UK estimates of human capital stocks in December 2010 (Jones and Chiripanhura (2010)), with further experimental estimates published in 2011 (Jones and Fender (2011)). Since then, developments to these human capital stock estimates have remained on-going and the estimates are currently available for both employed human capital and "full" human capital (which includes the unemployed), as well as breakdowns by age group, qualification, occupation, regional and gender.[11,12,13]

The estimation methodology uses data from the Annual Population Survey, covers the age range from the end of compulsory education (16 years of age) until the point of retirement (which is taken to be 65 years of age) and makes use of the life-time income approach to estimating human capital.

Based on the conceptual discussion above, we have to caveat the use of this data for the construction of the human capital satellite account as the part of the human capital formation done through the period of compulsory education would not currently be captured in the human capital stock estimate and the income data used is not fully aligned to the national accounts definition of compensation of employees. Drawing on the work of Corrado *et al.* (2020) could form the basis for correcting the UK human capital stock estimate to accommodate for the human capital formation that takes place within the compulsory education stage and therefore aligning the human capital formation with the compulsory education cost element. Further, alignment of the human capital life-time income with the national accounts concept of compensation of employees could be achieved. These points caveat our use of the current human capital stock estimates within a UK human capital satellite account and the development of these estimates within the context of the human capital satellite would be a subject for future research as outlined in the following sections.

The current estimate for reference year 2018 for nominal employed human capital is £20.84 trillion.

5.2.3 Data on compensation of employees

The compensation of employees' data is taken from the annual national accounts publication and is consistent with the published supply and use tables used to compile the education and training tables. This data is re-classified within the experimental human capital satellite account to give estimates of the human capital rental payments which allow for the return to human capital to be routed through to operating surplus within the sequence of accounts. As caveated in Section 5.2.2, the actual compensation of employees' concept does not fully align with the income definition used to calculate the human capital stock estimate. Conceptually the two should align as the human capital stock estimate is the discounted future income of the asset, so the in-period income of the human capital asset should equal the unwinding of the discount rate for that period. As stated above for the purposes of this paper we treat the entire estimate of compensation of employees as being

[11] ONS Human capital estimates are available at: Human capital estimates in the UK - Office for National Statistics (ons.gov.uk)
[12] ONS Human capital workplan is available at: https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/humancapitalworkplan/2018
[13] Results of ONS' consultation on human capital is available at: https://consultations.ons.gov.uk/well-being-inequalities-sustainability-and-environment/indicator-based-approach-to-measuring-human-capita/

attributable to the human capital asset, while acknowledging that the true proportion could fall within the range $0 < x \leq 1$ depending on the boundary between labour and human capital.

5.3 Experimental estimates of the changes arising from incorporating human capital assets in the supply and use framework and institutional sector accounts framework.

Section 5.2 above, sets out the information that can be readily obtained from UK published sources concerning estimates for education and training, current compensation of employees, and human capital asset stocks. These estimates are used to evaluate the required terms for the experimental human capital satellite account given in Section 5.1. These experimental estimates are made in full knowledge of the differences between the required conceptual term and what is available and that not all required terms could be populated currently, these are marked as necessary estimations for future developments and research within Table 9.

Using the estimates given in Table 9, we populate the changes arising within the supply and use tables (see Table 10 and Table 11 below) and the sequence of economic accounts (see Table 12 below) for reference year 2018. We then use the same methodology for other reference years to produce some time series analysis of the changes including human capital would have on gross value added, gross fixed capital formation and UK net worth.

Table 9: Estimates used within the experimental human capital satellite account

Transaction used	£m	Human capital asset satellite account term
Human Capital Asset[14]		
Opening balance sheet value (2017):	20,311,870 (£20.31 trillion)	HCA_{t-1}^{LT}
Closing balance sheet value (2018):	20,839,267 (£20.84 trillion)	HCA_{t}^{LT}
Estimates for the Education and Training Services [15]		
General Government final consumption expenditure on education/training	70,044	MHC^{G} (=$OJT^{G} + E^{G}(D)$)
Household final consumption expenditure change on education/training	25,977	$E^{H}(D)$
NPISH final consumption expenditure on education/training	28,491	MHC^{N} ($OJT^{N} + E^{N}(D)$)
Corporations intermediate consumption costs for training	13,259	MHC^{C} (= OJT^{C})
Compensation of Employees estimates by institutional sector[16]		
Corporations' compensation of employees	821,888	HCS_{H}^{C}+HCS_{M}^{C}
General government compensation of employees	190,351	HCS_{H}^{G}+HCS_{M}^{G}

[14] Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/humancapitalestimates/2004to2018

[15] Estimates taken from Table 8 above.

[16] Available at: https://www.ons.gov.uk/economy/grossdomesticproductgdp/compendium/unitedkingdomnationalaccountsthebluebook/2020/supplementarytables

NPISH compensation of employees	36,004	HCS_H^N+HCS_M^N
Compensation of employees paid to RoW	1,648	$HCS_M^C + HCS_M^G + HCS_M^N$
Compensation of employees received from RoW	1,262	HCS^X
Human capital gross investment (domestic) (approximated by difference in human capital assets – change between 2017 and 2018[17]):	527,397	HC_D^{LT}
Consumption of fixed capital on Human Capital Assets:	Needs to be estimated as part of future research	$P.51c^{HC}$
Revaluations of Human Capital Assets	Revaluations would be caused by: • Changes in life-time income per capita ($h_{s,e,a}^t$) Needs to be estimated as part of future research	$\sum_{s,e,a}\left(h_{s,e,a}^t - h_{s,e,a}^{t-1}\right) N_{s,e,a}^{t-1}$
Other changes in volume	Other changes in volume would be caused by: • Changes in assumed discount rate (r); and • Changes in assumed income growth rate. • Addition to human capital asset stock (Immigration): needs to be estimated as part of future research. • Deduction from human capital asset stock (emigration): needs to be estimated as part of future research.	n.a n.a HC_{Im}^{LT} HC_{Em}^{LT}

[17]This is a rough approximation to the annual gross investment in human capital, a more exact approach would calculate the gross additions to human capital assets controlling for immigration and emigration (using age, gender and qualification profiles). This was discussed further in Section 4.2.1 to 4.2.3, where we algebraically decompose the change in stock levels into its constituent components.

Table 10: Revisions to the Supply Table from the introduction of Human capital assets (£m)

£m		Producing Sector				Imports	Total Supply
Transaction	**Product**	**Corporations**	**Government**	**NPISH**	**Households**	**RoW**	
P.11	**Human capital intermediate input services**	+13,259	+70,044	+24,186			+107,489
	Human capital rental services				+1,047,857	+1,648	+1,049,505
P.12	**Output for own consumption (Human capital investment)**				+527,397		+527,397
P.13	**Non-market output**		-70,044	-24,186			-94,230
	Total output	+13,259	0	0	+1,575,254		

Table 11: Revisions to the Use Table from the introduction of human capital assets (£m)

£m		Consuming Sector				P.3			GFCF	Exports	Total Use
Transaction	**Product**	**Corporations**	**Government**	**NPISH**	**Households**	**Government**	**NPISH**	**Households**	**Households**	**RoW**	
P.2	**Human capital intermediate input services**	0	0	0	+133,466	0	0	-25,977	0	0	+107,489
	Human capital investment	0	0	0	0	0	0	0	+527,397	0	+527,397
	Human capital rental services	+821,888	+190,351	+36,004	0	0	0	0	0	+1,262	+1,049,505
P.13	**Non-market output**	0	0	0	0	-70,044	-24,186	0	0	0	-98,535
	Total intermediate consumption	+821,888	+190,351	+36,004	+133,466						
	Gross Value Added	-808,629	-190,351	-36,004	+1,441,788						
	D.1	-821,888	-190,351	-36,004							
	D.2 less D.3	0	0	0							
	B.2g	+13,259	0	0	+1,441,788						
	Total output	+13,259	0	0	+1,575,254						

Table 12: Revisions to the institutional sector accounts from introducing Human Capital Assets (£m)

Use					Production Account (£m)	Resource				
Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy
					Domestic Output					
					Market output	+1,047,857	+24,186	+70,044	+13,259	+1,155,346
					Output for own consumption	+527,397				+527,397
					Non-market output		-24,186	-70,044		-94,230
1,181,709	+821,888	+190,351	+36,004	+133,466	Intermediate Consumption					
+406,804	-808,629	-190,351	-36,004	+1,441,788	Gross Value Added					

Use					Generation of Income Account (£m)	Resource				
Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy
					Gross Value added	+1,441,788	-36,004	-190,351	-808,629	+406,804
-1,048,243	-821,888	-190,351	-36,004		Compensation of Employees					
					Taxes less subsidies on production					
+1,455,047	+13,259	0	0	+1,441,788	Gross Operating Surplus					

Use						Allocation of primary income Account (£m)	Resource					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
						Gross Operating Surplus	+1,441,788	0	0	+13,259	+1,455,047	
-1,262						Compensation of Employees	-1,047,857	0	0	0	-1,047,857	-1,648
						Property income						
-1,262	+407,190	+13,259			+393,931	Balance of primary incomes, gross						

Use						Secondary distribution of income Account (£m)	Resource					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
						Balance of Primary incomes, gross	+393,931	0	0	+13,259	+407,190	
	+107,489	+13,259	+70,044	+24,186		Current Transfers	+107,489	0	0	0	+107,489	
	+407,190	0	-70,044	-24,186	+501,420	Disposable income, gross						

Use						Use of income Account (£m)	Resource					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
						Disposable income, gross	+501,420	-24,186	-70,044		+407,190	
	-120,207		-70,044	-24,186	-25,977	Final consumption expenditure		0	0	0		
	+527,397		0	0	+527,397	Saving, gross						

Changes in Assets						Changes in net worth due to saving and capital transfers (£m)	Changes in liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
						Saving, gross	+530,000				+530,000	
						Capital transfers		0	0	0		
	+527,397				+527,397	Changes in net worth due to gross saving and capital transfers						

Changes in Assets						Acquisition of non-financial assets account (£m)	Changes in liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
						Changes in net worth due to saving and capital transfers	+527,397				+527,397	
	+527,397				+527,397	Gross Fixed Capital formation		0	0	0		
	0				0	Consumption of fixed capital						
	0				0	Net lending/net borrowing						

Assets						Opening Balance sheet (£m)	Liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
	+20,311,870				+20,311,870	Human Capital						
						Net worth	+20,311,870	0	0	0	+20,311,870	

Changes in Assets						Changes in net worth due to saving and capital transfers (£m)	Changes in liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
	+527,397				+527,397	Human Capital						
						Changes in net worth due to saving and capital transfers	+527,397	0	0	0	+527,397	

Changes in Assets						Changes in net worth due to other changes in volume of assets (£m)	Changes in liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
						Human Capital						
						Changes in net worth due to other changes in volume of assets		0	0	0		

Changes in Assets						Changes in net worth due to nominal holding gains and losses (£m)	Changes in liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
						Human Capital						
						Changes in net worth due to nominal holding gains and losses		0	0	0		

Assets						Closing Balance sheet (£m)	Liabilities and net worth					
Rest of the World	Total Economy	Corporations	Government	NPISH	Households		Households	NPISH	Government	Corporations	Total Economy	Rest of the World
	+20,839,267				+20,839,267	Human Capital						
						Net worth	+20,839,267	0	0	0	+20,839,267	

Table 13 provides a comparison of the estimated change to the UK main aggregates from including human capital, as detailed in Table 10 to Table 12 above, within the national accounts frameworks, for reference year 2018. Firstly, the UK experimental human capital satellite account gives the expected result of the change to net lending/borrowing being zero, with the implication that the incorporation of human capital assets has no impact on the UK financial account and financial balance sheets due to all the necessary financing of human capital formation and use of human capital services already being captured within the national accounting framework. In reference year 2018, the incorporation of human capital assets on to the balance sheet would increase UK's net worth by £20.84 trillion or a 204.79% increase from the current net worth estimate of £10.18 trillion. The estimated UK human capital stock for reference year 2018, as a percentage of all current UK non-financial assets is 198.47% (Canada reported human capital stock estimates of 50% of Canadian non-financial assets, reference year 2010, UNECE (2016)). Through the inclusion of human capital assets, UK gross fixed capital formation would increase by £530 billion or 138.33% of the current gross fixed capital formation estimate (Canada reported 76% increase, reference year 2010, UNECE (2016)). The UK's higher percentage increase in gross fixed capital formation when compared to Canada's could be due to the known inclusion in the experimental gross investment in human capital of nominal revaluations and the different reference years of the experimental work. The inclusion of revaluations within the experimental estimate of gross investment in human capital will also be a contributing factor to the volatility seen in the time series estimates including human capital given below. It also needs to be remembered that the current experimental gross investment in human capital and human capital stock estimate will also be an underestimation due to it not including the investment in human capital arising from the < 16 years of age. For the current human capital stock estimate this is by design, the current stock estimates focus on the working age population but for the human capital satellite account this creates an inconsistency with the < 16 years of age education intermediate input to the household human capital production function, as discussed above.

Table 13 Changes to UK main aggregates from the introduction of Human Capital Assets into the UK institution sector accounts (reference year 2018).

Main aggregate	Experimental estimated change for domestic economy, S.1 (£m)	Current value of variable for domestic economy, S.1 (£m)	Experimental estimated change for S.1 as percentage of current variable (%)
Gross value added	+406,804	1,910,247	21.30
Gross operating surplus	+1,455,047	693,900	209.69
Balance of primary incomes, gross	+407,190	2,113,914	19.26
Disposable income, gross	+407,190	2,088,426	19.50
Saving, gross	+527,397	304,314	173.31
Changes in net worth due to saving and capital transfers	+527,397	301,942	174.67
Gross fixed Capital formation	+527,397	381,249	138.33
Net lending/net borrowing	0	-82,075	0.00
Net worth	+20,839,267	10,176,340	204.79

Through replicating the above methodology for the reference years 2005 – 2017 we can generate time series for revisions to a selection of economic aggregates from incorporating human capital assets into the national account framework within the experimental UK human capital satellite account; these are discussed in the following section.

5.4 Time series analysis of human capital satellite account impact on economic aggregates.

The first general observation from analysing the time series is that human capital has large impacts on the economic aggregates, in both flow and stock terms; see Figure 2 to Figure 10 below. Secondly, the current revisions from including human capital assets into the framework of transactions are relatively volatile, which is not immediately evident when looking at human capital stock levels only. This volatility could be for three main reasons. Firstly, current estimates of human capital stocks only include the working age population and therefore we have a cohort effect as groups of children reach 16 years of age and enter the working age population and their human capital is counted for the first time rather than having a steady build-up of their human capital through the ages of 4-15, which could have a smoothing effect. We note that the current published human capital estimates are perfectly correct for their purpose. This only becomes an issue for human capital satellite purposes as we need to account for inputs used to produce human capital, which includes education of < 16 years of age. Secondly, we have captured within the flows an element of immigration/emigration which should be treated as an 'other volume' change which gain could add to the volatility if the movement into and out of the UK is not smooth. Finally, the current flow estimates could be capturing price effects due to not being able to remove revaluations from the flows, which again could be adding to the volatility. On reflection, we feel the biggest impact on the volatility would be the sudden appearance of human capital assets at age 16 years of age rather than having a smooth build up from age 4 within the human capital estimates.

The following provides some brief comment and analysis on the revision to selected economic aggregates.

5.4.1 Revision to nominal UK gross value added through the inclusion of human capital.

Figure 2 shows a comparison between current estimates of UK nominal gross value added and the experimental UK nominal gross value added including the value added from the production of human capital assets. The inclusion of human capital within the production boundary leads to a UK nominal gross value-added level revision of between +1% and +34% depending on the reference year. This shows some of the degree of volatility introduced from the current experimental human capital value added. The source of this volatility is the experimental estimate of the domestic output from the household production of human capital in comparison to the total education and purchased training inputs. Figure 3 shows a comparison between experimental domestic output of human capital assets and what we've taken as the intermediate service inputs of education and purchased training. Figure 3 shows that the experimental intermediate services input to human capital production is relatively smooth and the volatility is in the domestic output of human capital

(which equals the gross investment in human capital within the reference year) and hence into the contribution of value-added from human capital. This volatility was discussed above within the general observations of the revisions from including human capital. This volatility in the nominal gross value-added including human capital is increased when we compare the growth rates in nominal gross value added before and after including the experimental human capital estimates, see Figure 4. Analysing the nominal gross value-added growth rate including human capital's contribution we see that in nominal terms the financial crisis recession in 2008 – 2009 would have been exacerbated and the UK would have been in recession in 2016 – 2017, with a strong recovery into 2018.

Figure 2: Comparison of the current UK estimate of nominal gross value added with the experimental estimate of nominal gross value-added including contribution from human capital assets.

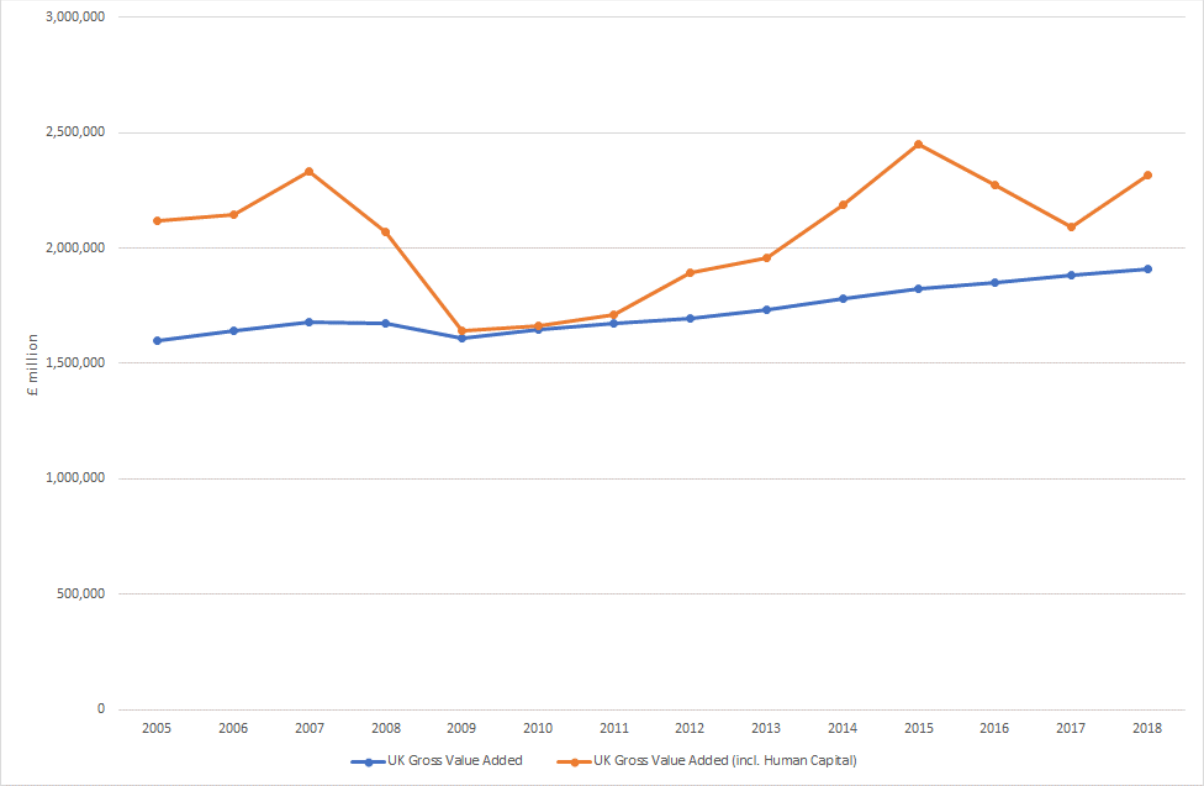


Figure 3: Comparison of approximate human capital gross investment and total education and purchased training intermediate inputs

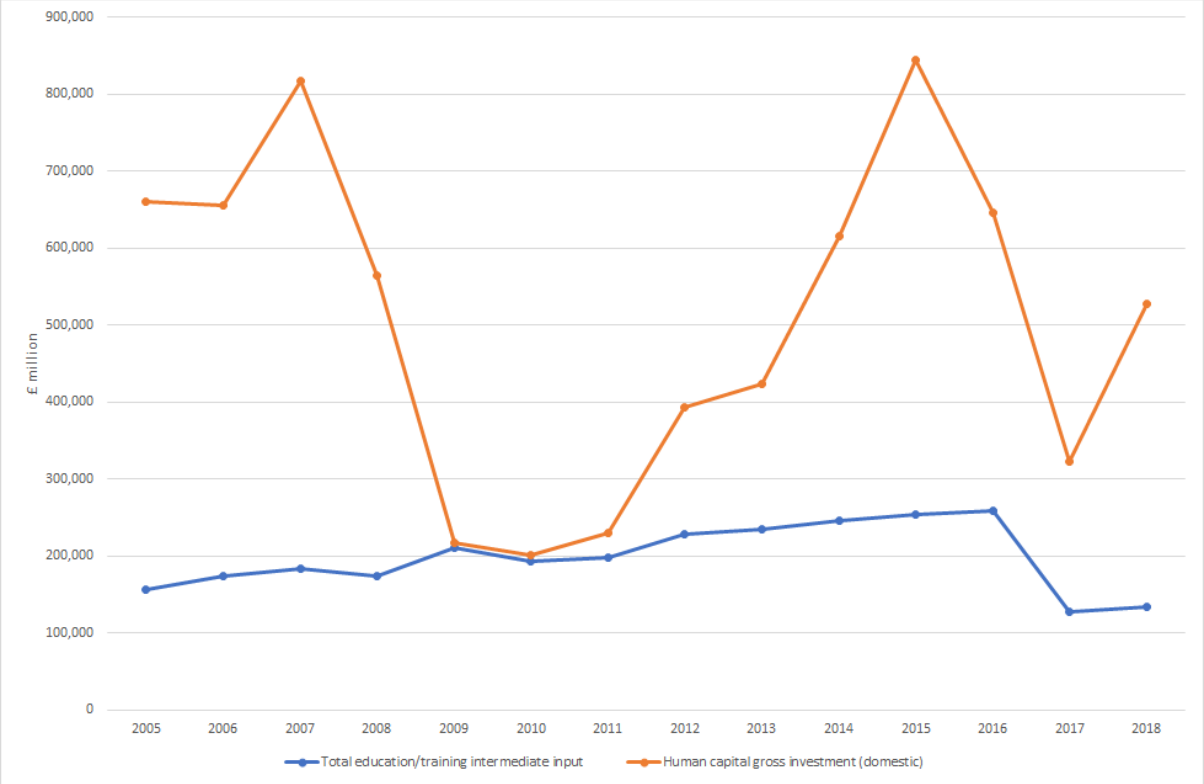
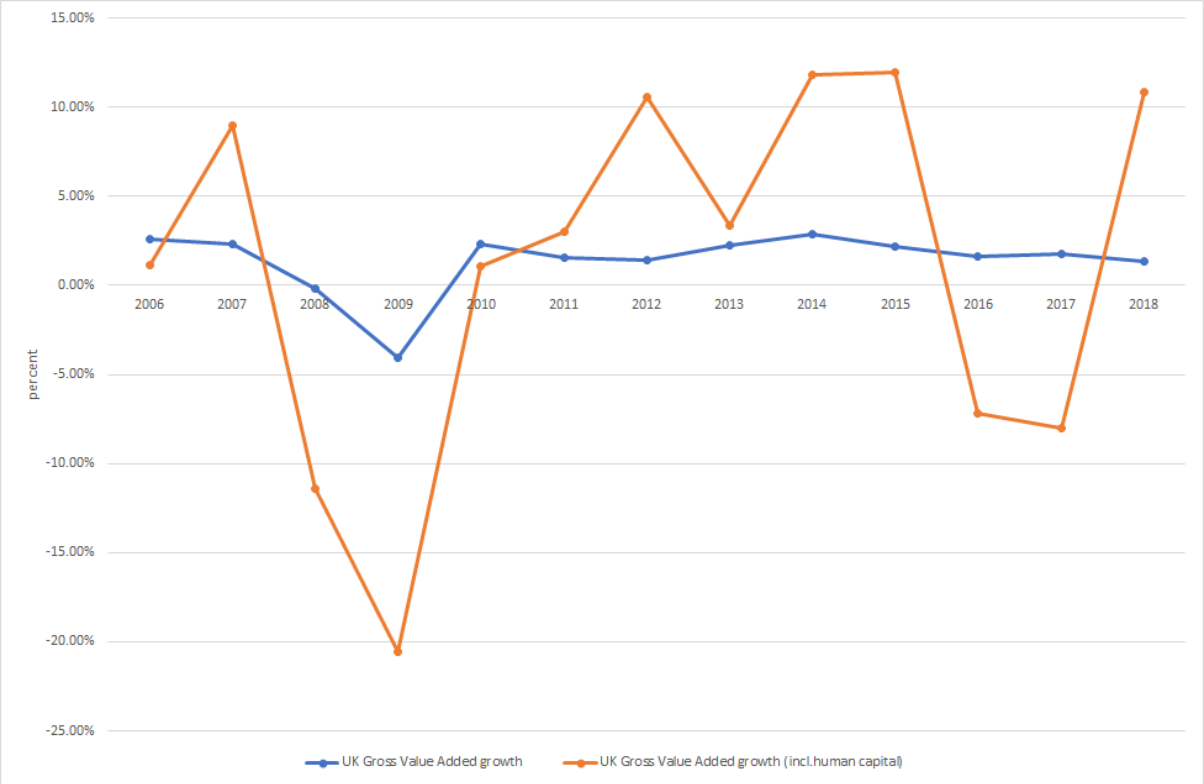


Figure 4: Comparison of current UK growth in gross value added with experimental estimated growth in gross value-added including contribution from human capital assets.



5.4.2 Revisions to UK gross fixed capital formation through the inclusion of human capital.

Figure 5 shows the comparison with current UK nominal gross fixed capital formation and experimental UK nominal gross fixed capital formation including human capital and Figure 6 shows the experimental UK nominal gross fixed capital formation including human capital as a percentage of current UK total nominal gross fixed capital formation. These two graphs show a similar story of the degree of level shift by including human capital and the economic aggregates increases in volatility, compared with the smooth time path of the current total UK gross fixed capital formation estimate. The human capital asset gross fixed capital formation as a percentage of current UK total gross fixed capital formation ranges from 78% to 295% depending on the reference year.

Figure 5: Comparison of current estimate of gross fixed capital formation with experimental estimate of gross fixed capital formation including gross investment in human capital.

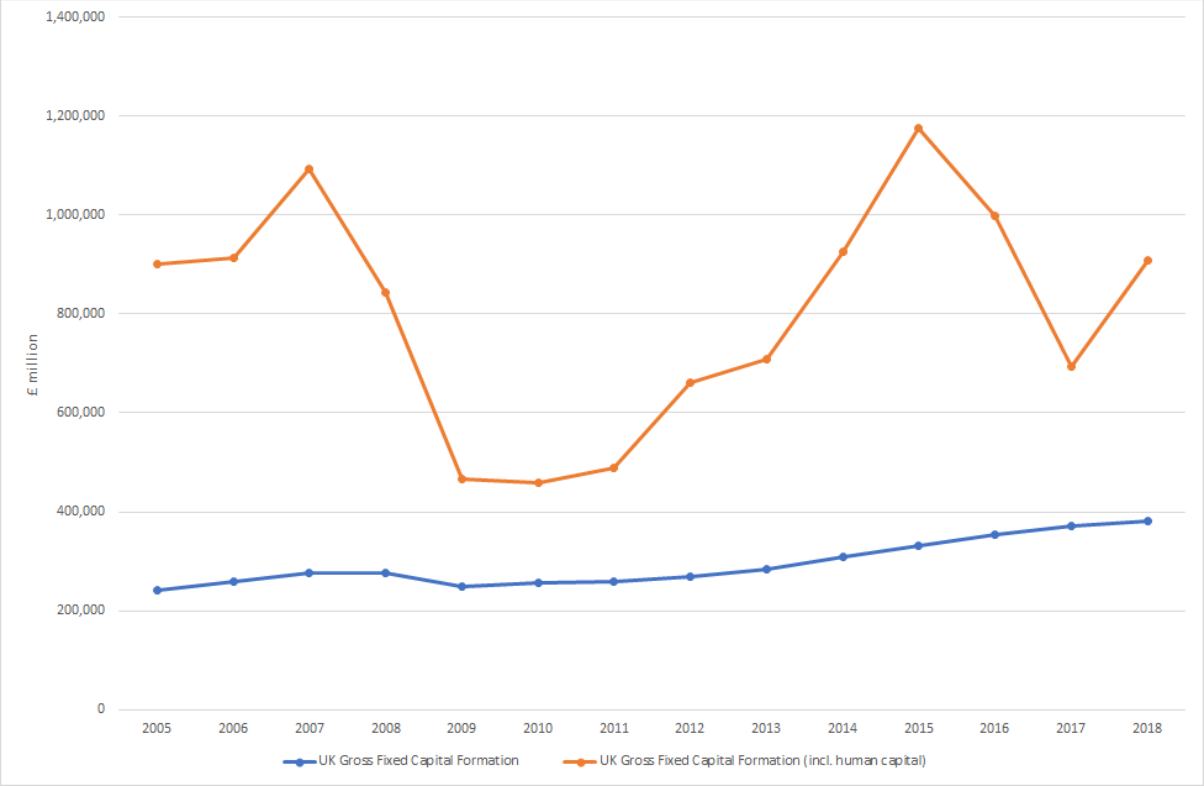
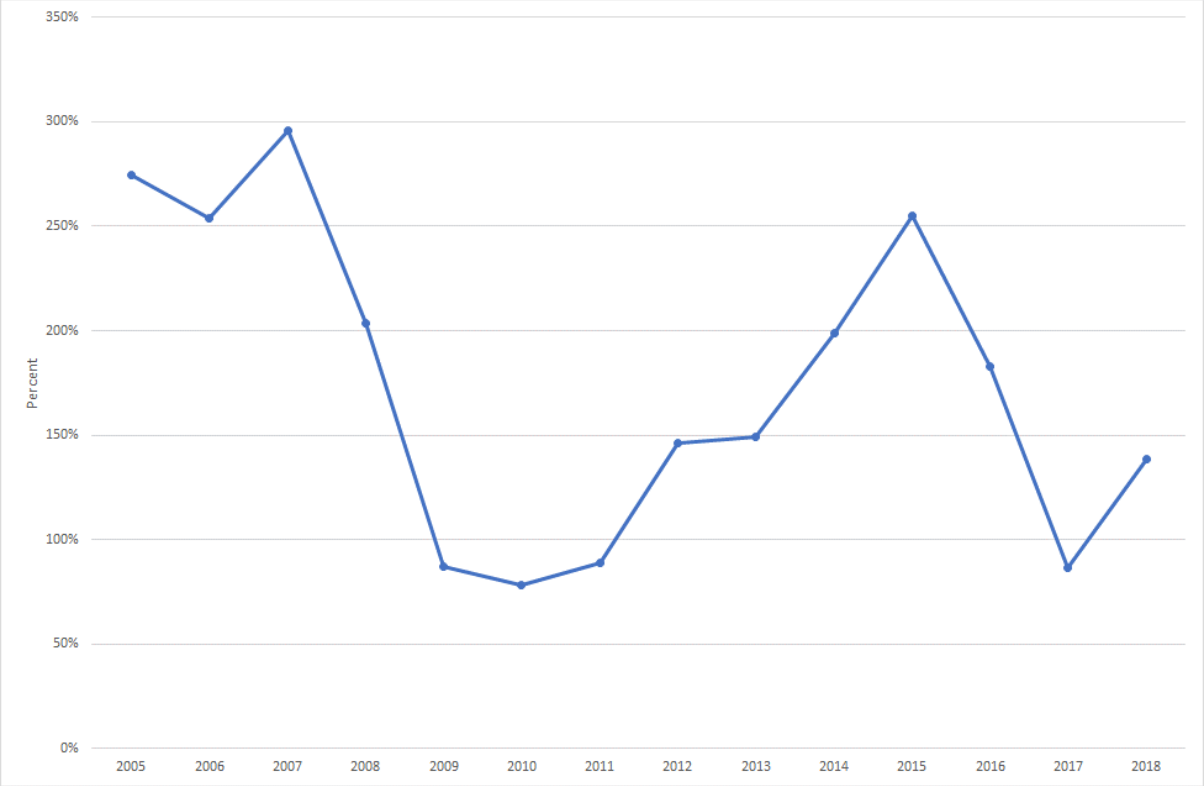


Figure 6: Human Capital gross fixed capital formation as a percentage of current UK gross fixed capital formation



5.4.3 Revisions to UK net worth through the inclusion of human capital assets.

This last section considers the revisions to the UK balance sheets from including human capital assets, in particular the impact on UK net worth (Figure 7, Figure 8 and Figure 9) and the relative size of human capital assets compared to all other non-financial assets on the balance sheet (Figure 10).

The most obvious impact of including human capital assets on to the UK balance sheet is the size of the human capital asset. This causes a substantial positive revision to the level of UK net worth, with the human capital assets being between 205% to 251% the size of current UK net worth depending on reference year considered. When compared in per capita terms UK net worth including human capital assets ranges between £343,651 per capita and £466,852 per capita, depending on reference year, compared with £105,603 per capita and £153,176 per capita for the current UK net worth per capita (see Figure 9). Finally, current human capital assets estimates are between 198% and 241% of total UK non-financial assets currently recorded on the UK balance sheet depending on reference year.

Figure 7: Comparison of current UK net worth with experimental UK net worth including human capital assets.

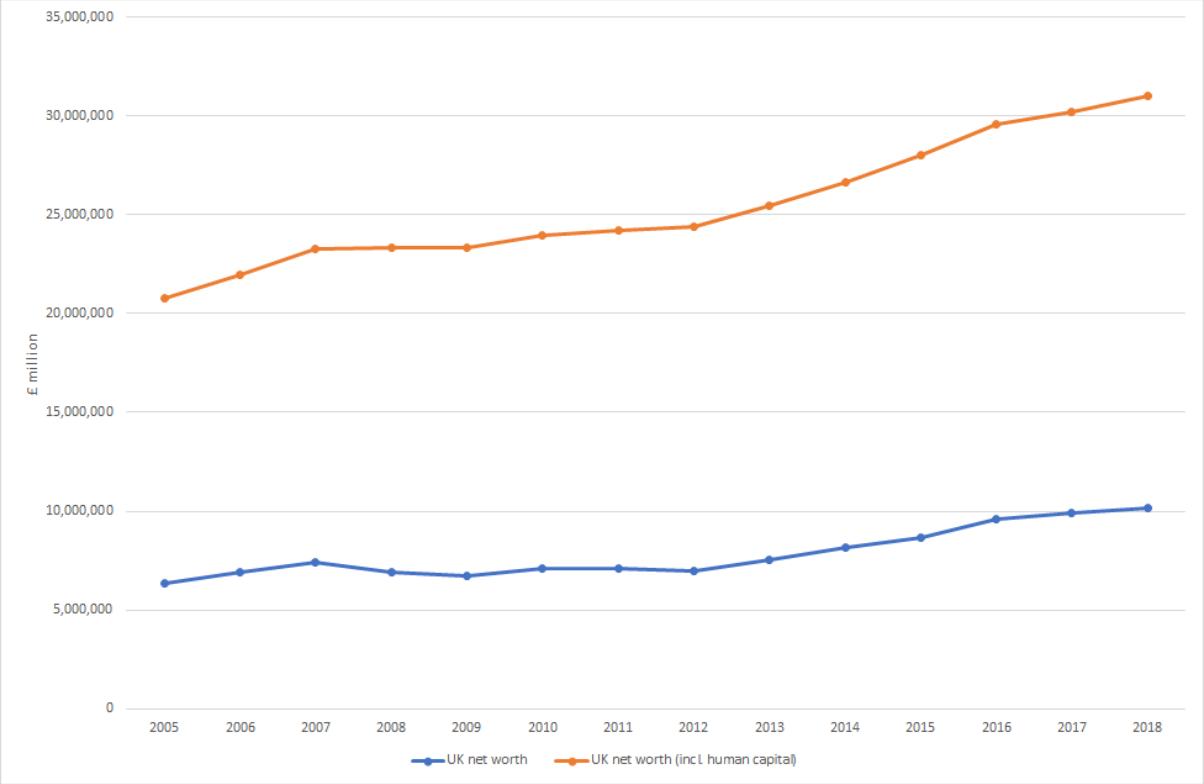


Figure 8: Human Capital Assets as a percentage of UK net worth

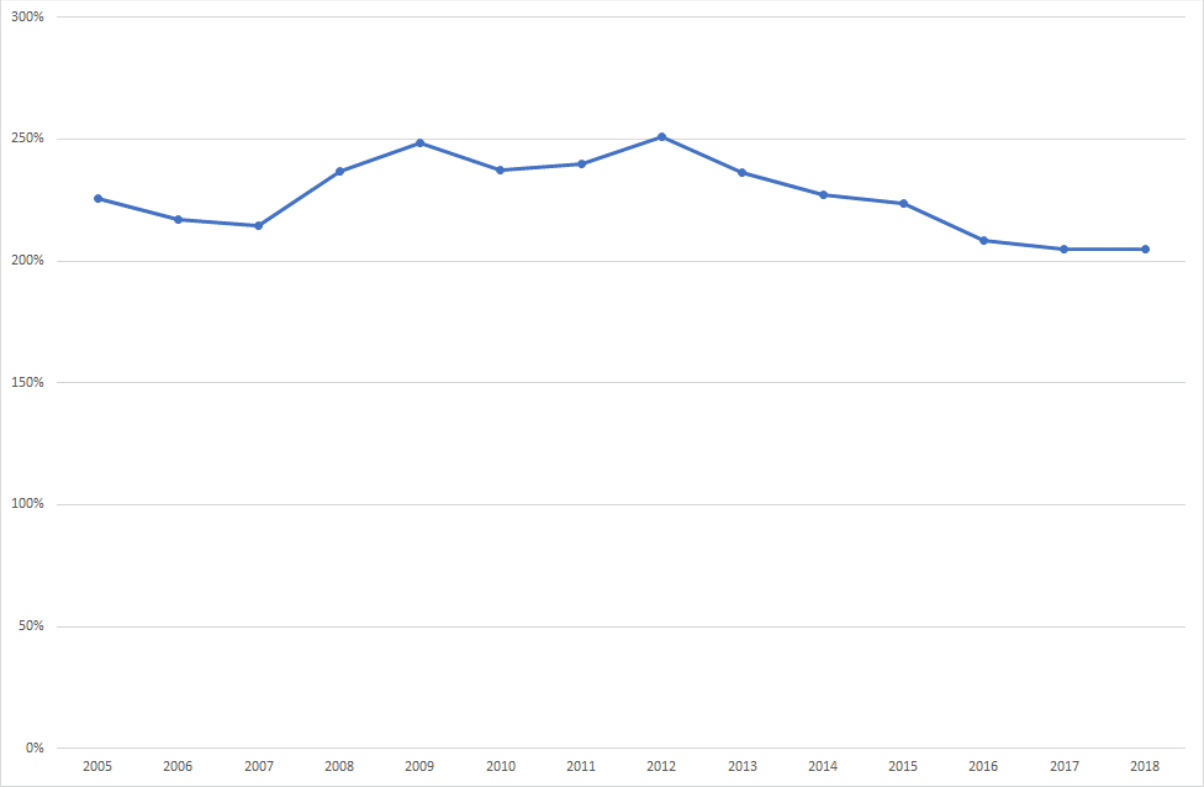


Figure 9: Comparison of UK net worth per capita and experimental UK net worth per capita including human capital assets

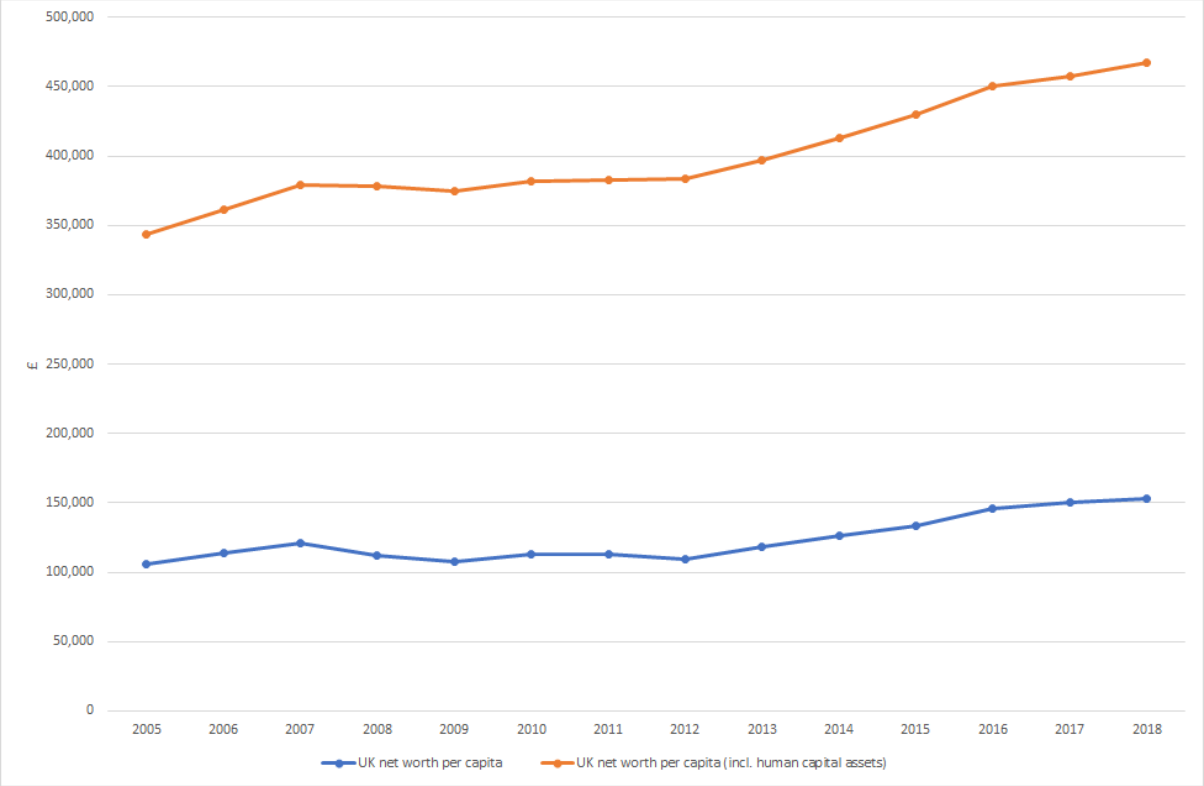
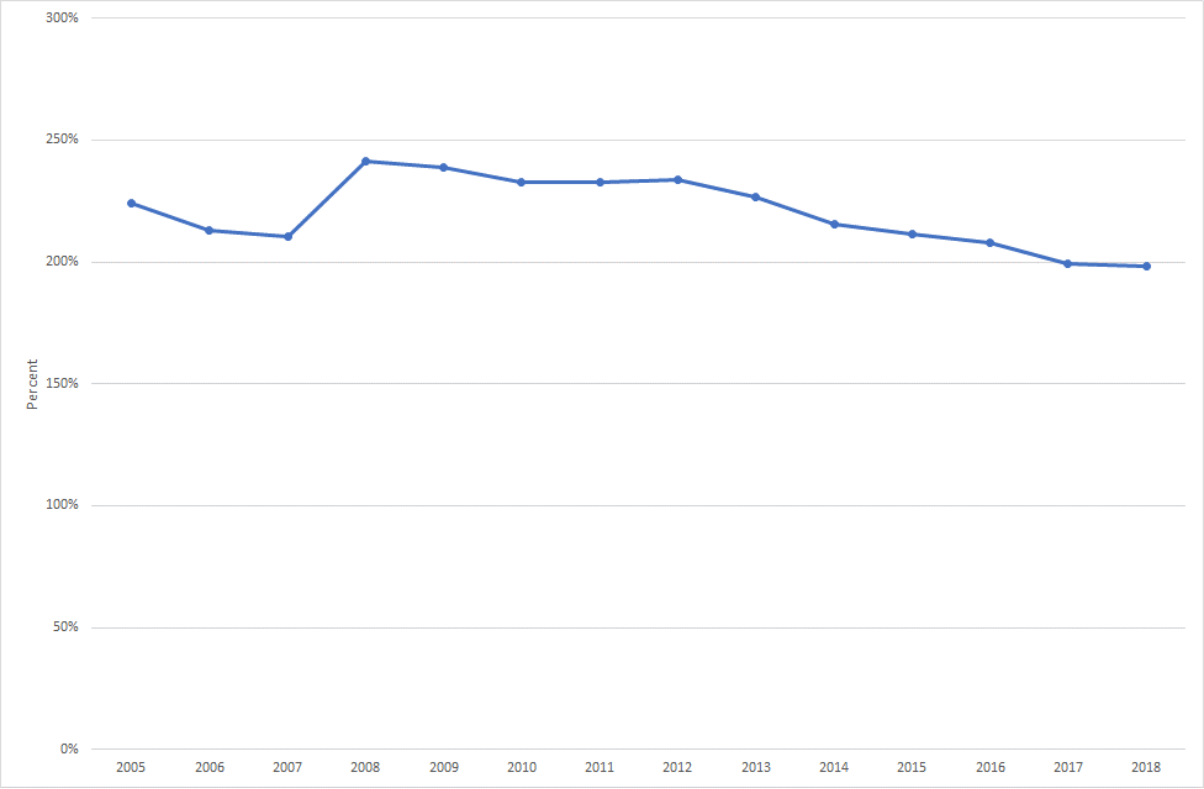


Figure 10: Human Capital Assets as a percentage of total UK non-financial assets



6. Human Capital Satellite Account and Multi-factor productivity.

We have shown above that it is possible to define and populate the process for the formation of human capital asset through the sequence of accounts; even though there are issues and difficulties in doing so, which mean the experimental estimates need caveating. We have also moved beyond that, by giving the first broad estimates, using publicly available data, of what the incorporation of human capital assets would do to the main balancing items in the accounts such as GVA, gross national income and gross saving. This exercise is not only essential by its value in defining and estimating human capital per se but also due to the potential implications it will have for multi-factor productivity analysis.

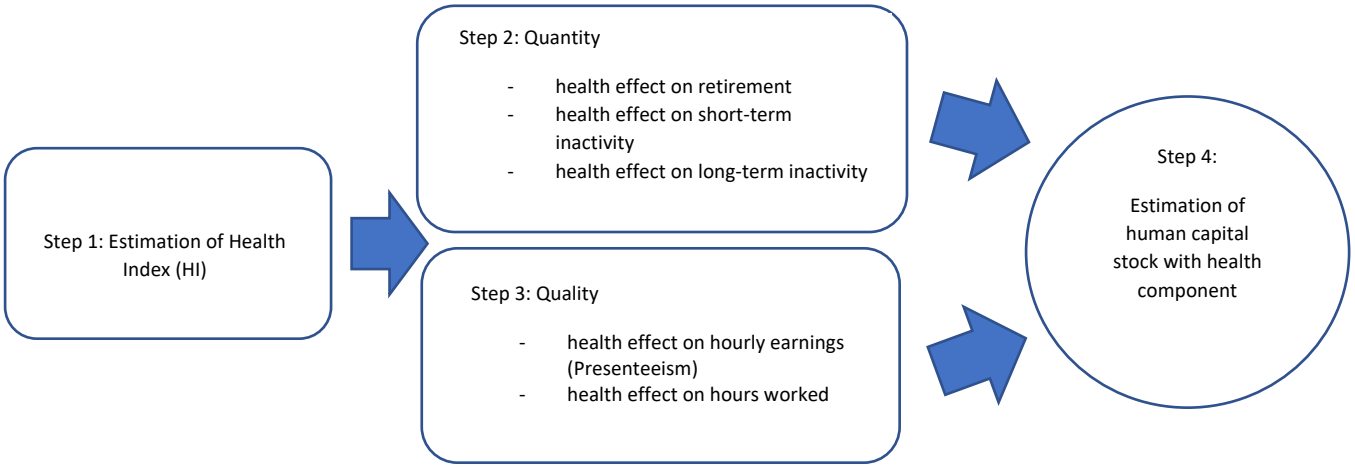
The first direct consequence is that the input into the production function shifts from being a strictly labour input to being a human capital asset input. This means for multi-factor productivity, like for all other produced non-financial assets, we need to know the productive human capital stock level and not the nominal net stock level, as produced from the life-time income approach model, to be able to produce human capital services for productivity analysis as a replacement for Quality Adjusted Labour Indices (QALI).

The life-time income model has for a given attainment level and gender, an age-price (life-time income per capita by education, gender and age) profile which is then discounted to the present value and summed across age, gender and attainment level to give the nominal human capital net stock level (see Equation 1 above). To be able to convert the nominal human capital net stock level to the productive stock level for productivity analysis we need to move from an age-price profile to an age-efficiency profile for the human capital asset, to be able to estimate human capital services. This age-efficiency profile would need to specify the productivity of human capital for a given attainment level, gender and age, the variable that would most likely do that would be the health of an individual. The relationship between health and human capital has been developed and discussed by O'Mahony and Samek (2021) and we briefly discuss their findings and modelling in the next section, while leaving the estimation of human capital services and the implications for multi-factor productivity to future research.

6.1 Health and Human Capital Services

The impact of health on human capital has been discussed by O'Mahony and Samek (2021), so we will not consider it in detail apart from presenting a summary of the results achieved and the overview of the modelling approach. The results presented in this paper show that overall poor health leads to a reduction in human capital stocks (what we would see as the productive human capital stock levels) by about 12% in 2018, but shows a slight tendency to decrease over time, mostly driven by trends in inactivity due to long-term illness, and retirements for those aged over 50. The results presented, varying by qualification level, gender and age, with productive human capital stock decreasing by about 45% for individuals aged 50 years or older with low qualifications. These results were achieved by modelling the impacts of health on human capital in four stages, these are given in Figure 11.

Figure 11: Overview of O'Mahony and Samek (2021) research approach



O'Mahony and Samek (2021); Figure 1; p.3.

This research approach and application to UK data demonstrates how health effects can be incorporated into modelling of productive human capital stock estimates, which is a necessary step towards estimating the human capital services required for multi-factor productivity analysis.

7. Conclusions and Further Research

This paper set out to produce for the first time a UK human capital satellite account to help to explain the movement between the currently produced human capital stock estimates and the consequences of including human capital assets into national account frameworks. In doing this the paper addressed some of the issues raised by Bucknall *et al.* (2021) regarding human capital estimates and how it would conceptually fit into the national accounts' framework. Through bringing human capital within the SNA production and asset boundary within a satellite account structure, we highlighted some conceptual issues which we feel would need to be addressed for human capital to fully be incorporated into the national accounts. These issues can be summarised as follows:

- What is the dividing line between labour and human capital and therefore what is compensation of employees (D.1) and what is a human capital rental service?
- What is the mark-up for net operating surplus for education services provided by the non-market sector when we reclassify it from non-market output to market output so that it can be an intermediate input to the household?
- Is treating work experience as the source of value-added acceptable or does the household human capital cost function need an opportunity cost estimate for the time taken to build up the work experience?
- The need to include within the estimate of human capital those aged under 16 years of age to be consistent with the education services input.
- Does the available data sources allow for estimation of the "other volume" changes for immigration/emigration and movement between economically active (and therefore contributing to production of gross value-added) and non-economically active prior to retirement?

In this paper we have either accepted a deficiency or made an assumption to allow for the production of the experimental human capital satellite account based on published economic and human capital statistics. This is the early stages of introducing a human capital satellite account, the paper acknowledges the areas where further developments are required to improve either the deficiencies and/or refine the assumptions made to achieve a more coherent satellite account in the longer term. Though the current experimental estimates do show the importance of human capital assets for the main economic aggregates. One of these improvements would be to construct our own model for producing human capital estimates to allow for experimentation and research with a focus on producing estimates to meet the requirements of the human capital satellite account. Future research could also investigate whether it makes sense to move away from the umbrella term of human capital and instead talk through the estimation of different types of human capital assets, such as an education asset, a vocational training asset, a vocational experience asset, etc., rather than just a human capital asset, i.e. incorporating sub-assets which form the human capital asset aggregate.

Even acknowledging the above issues and limitations of the experimental UK human capital satellite account, we have shown that the incorporation of human capital assets within the SNA production and asset boundary is conceptually possible and has far reaching consequences. The importance of human capital assets for the sequence of economic accounts has been demonstrated based on the potential size of the asset; human capital assets are on average 220% of total current UK non-financial assets on the UK balance sheet or an average of 227% of the current UK net worth estimate over the reference period of 2005-2018.

Finally, we discussed the necessary link between health and productive human capital stock as given in O'Mahony and Samek (2021). O'Mahony and Samek (2021) showed that overall poor health leads to a reduction in human capital by about 12% in 2018 and that the productive human capital stock was reduced by about 45% for individuals aged 50 years or older with low qualifications. We briefly discussed that this research into the relationship between health and human capital assets is important as it is analogous to an age-efficiency profile of other produced assets and that having the productive human capital stock is a precursor to estimating human capital services which is the necessary variable for incorporating human capital assets into multi-factor productivity analysis; with this introduction of human capital assets into productivity analysis being a point of further research.

In summary, this paper has set out how human capital assets can be incorporated into a sequence of economic accounts to show the evolution between two human capital stock positions within the economic accounts, what the issues of doing this are both conceptually and the data difficulties, and provides some early estimates based on currently published data which illustrates the size and importance of human capital within the economic accounts. These experimental estimates are the first of their kind for the UK and further research and discussion, both domestically and internationally, on how best to refine the quality of estimation needs to be undertaken to address the conceptual and measurement issues raised in this paper.

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