Measuring education services using lifetime incomes

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Keywords: Education, Intangibles, Human Capital

JEL codes: E01, I20, O47

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1. Introduction

This paper estimates the value of education services and compares this to education expenditure, using the lifetime income approach put forward by Jorgenson and Faumeni (1989, 1992a, 1992b). We see this as an alternative to the more conventional approaches that use quantity indicators, such as number of pupils in schools, or that measure outputs by inputs. It integrates education received at various levels - primary school, secondary school, further education and higher education - into a coherent framework that measures education services using outcomes. Therefore it can take account of the interactions between education levels, since good performance at lower levels of education lead to a greater probability of entering higher levels. The paper addresses a number of issues in modelling education output in this way, in particular the extent to which earnings outcomes can be attributed to formal education rather than subsequent knowledge acquisition in the form of training or on the job learning.

Section two sets out the lifetime income model, which underlies our calculations. We then apply this approach to data for the UK over the period 1993 to 2018. Section three discusses the data used and the main results. Section four considers two extensions, the treatment of foreign students and relating education outcomes to government expenditure, a measure of productivity. Section five sets out the conceptual framework for modelling education services as social infrastructure which could be integrated in the national accounts. Finally, we conclude in section six.

2. The Jorgenson Fraumeni framework

This section suggests a method of integrating the JF (1989, 1992a, 1992b) lifetime income approach to measuring human capital into a measure of education services. The JF framework is set out below, followed by a discussion of conceptual issues that arise when using the framework to estimate the output of the education sector.

2.1. The Jorgenson-Fraumeni framework

2.1.1 Lifetime income

We begin by abstracting from non-market activities, employment outcomes and labour force dropouts and simply assume that any student enrolled in school will in the following year, if they leave education, earn the market wage corresponding to that level of education.

The JF framework calculates the value of human capital stocks based on lifetime incomes by sex ($s$), age ($a$) and education level ($e$). Their original papers calculate this for all persons in the population. A more common approach is to calculate the stock only for the working population (e.g. Gu and Wong, 2010, as well as Wei, 2004). In this paper we begin with the active population, removing those age groups where school is compulsory, aged < 16, and those where all persons have retired permanently from the workforce, which we take as aged > 80.
Let:

- $y$ = current market income
- $li$ = lifetime income
- $\delta$ = discount rate
- $g$ = average income growth
- $senr$ = enrollment probability
- $sr$ = survival rate
- $pop$ = population.

The JF framework calculates lifetime income by sex, age and education for essentially two groups, those who no longer acquire formal education and those who might stay on in education and so increase their lifetime earnings. For simplicity, it is assumed that no individuals from age 40 are enrolled in education. The first group, for those aged 40 and over, is the most straightforward. The simplest assumption is to say that lifetime income is 0 beyond some age, say 80. For those aged 80, lifetime income ($li$) in year $t$ is just current labour income ($y$).

(1) 

$$li_{s,a=80,e,t} = y_{s,a=80,e,t}$$

For those aged 79 lifetime income is current labour market income plus discounted future income of those aged 80 with the same education and gender, conditional on survival:

(2) 

$$li_{s,a=79,e,t} = y_{s,a=79,e,t} + sr_{s,a=80,e,t} \frac{1+g}{1+\delta} y_{s,a=80,e,t}$$

In general the lifetime income of those aged 40 or older is given by:

(3) 

$$li_{s,a,e,t} = y_{s,a,e,t} + sr_{s,a+1,e,t} \frac{1+g}{1+\delta} li_{s,a+1,e,t} \quad | a \geq 40$$

This valuation for individual $i$ at time $t$ is the value of current income plus the income of those one year older of the same sex and educational attainment times growth in income discounted to the present, plus the income of those two years older and so on up to age 80. It therefore assumes that the best estimate of a person's income next year is that earned this year by a similar person (same gender, education) who is one year older.

For persons aged between 5 and 39, lifetime income takes account of if they are enrolled in education ($senr$) or not ($1 - senr$). For these age groups:

(4) 

$$li_{s,a,e,t} = y_{s,a,e,t} + sr_{s,a+1,e,t} \frac{1+g}{1+\delta} \left[ senr_{s,a,e,t} li_{s,a+1,e+1,t} + (1 - senr_{s,a,e,t} li_{s,a+1,e,t}) \right] \quad | 5 \leq a < 40$$

Thus, if a person aged $a$ is enrolled in education level $e$, their lifetime income depends on that for a person one year older with level $e + 1$. If the same individual is not enrolled in education, their lifetime income depends on that for an individual one year older with education level $e$. Finally, lifetime income for those aged 0 to 4 is calculated the same way as for those aged 40 and over except that earnings are zero and education is set at the lowest level.
The assumption that the best estimate of a person’s future income is that of a similar person one year older is contentious. This may not hold in practice due to changes in demand and supply affecting different cohorts. On the supply side if there is a large expansion of education in some cohorts, their returns will likely decrease and their expected future income might not be equivalent to older cohorts with the same education. Or there may be complementarities between different types of workers, which would affect their relative returns - see Jones (2014) for a cross country analysis of complementary skills. Against this if new technology increases the demand for younger people, they might earn more than older cohorts. Bowlus and Robinson (2012) suggest a method to estimate vintage effects whereby new graduates may differ in terms of the labour services per hour that they supply, relative to previous cohorts. Their results for the US suggest large positive cohort effects for college educated workers. Papakonstantinou (2017) estimates similar results for the UK. In this paper we continue to use the constant labour services assumption but plan to revisit this in future work.

2.1.2 Value of human capital

The total value of the human capital stock in year $t$ can be calculated by summing the lifetime earnings by $s$, $a$ and $e$:

\[
P_t^H H_t = \sum_s \sum_a \sum_e \text{pop}_{s,a,e,t} \, l_{s,a,e,t}
\]

where $H$ is the real stock and $P^H$ its price. In measuring the nominal value of education as investment in social infrastructure we concentrate on the portion of the population enrolled in education. Following Christian (2010), we estimate the value of investment from education of persons enrolled in educational establishments, $P_t^E Q_t^E$ as:

\[
P_t^E Q_t^E = \sum_s \sum_a \sum_e \text{enr}_{s,a,e,t} \left( l_{s,a+1,e+1,t} - l_{s,a,e,t} \right)
\]

Enrollments ($enr$) are multiplied by the amount by which lifetime earnings at that age, sex and education change with the addition of one extra year of education and the one extra year of age required to achieve that additional education. In the estimation of lifetime incomes, we set $g = 2\%$ and $\delta = 3.5\%$ which are the usual assumptions employed in human capital stock calculations (Jones and Fender, 2011; Christian, 2010; Gu and Wong, 2010). The value of 3.5\% for the discount rate is consistent with that employed in the HM Treasury Green Book, HM Treasury, 2018. Note that in equation (6) we are taking the difference between two lifetime earnings which depend on common values for $g$ and $\delta$. Therefore, the impact of assumptions on the values of these two parameters is not an issue in these calculations. This is in contrast to the values of human capital stocks which are very sensitive to the parameter values (Jones and Fender, 2011).
### 2.2. Valuing net investment in human capital for persons enrolled in education

There are a number of issues to resolve in order to value equation (6). The most important include the attribution of lifetime earnings to education and the utilisation of human capital through employment propensities and reductions due to dropouts. In what follows we also discuss the nature of the education progression of students, and volume measure and corresponding deflators.

#### 2.2.1. Attribution

What is the income of a person one year older with the same education level capturing? In Mincer’s canonical wage equation (Mincer, 1974) in which individual $j$’s wage is a return to human capital, there are two key terms: one is a return to schooling and the other one a return to work experience. This suggests that, for individual $j$ we have, $H_{j,t} = E_{j,t} + LX_{j,t}$ where $H_{j,t}$ is individual $j$’s total real human capital and $LX_{j,t}$ is the portion acquired through work, i.e. labour market, experience. From the point of view of the schooling system, this suggests schooling-produced knowledge assets can be defined as the present discounted value of expected wages of those leaving education upon entry to the labour market, i.e. when the return to experience is virtually nil. Then the income stream arising from education services should be constant at the graduation earnings through time. In that case the lifetime income stream only depends on how long the person is in the workforce after completing education.

The other extreme is to assume that all future labour income is attributable to the level of educational attainment of the individual. This amounts to using the full JF calculation. However, in our context it is difficult to justify this assumption.¹ A practical solution might be to derive the wages on graduation as a $T$-year average from the point of graduation. This could be justified by assuming some degree of asymmetric information whereby firms do not pay the full marginal product immediately in case the worker turns out to be a lemon. We set $T$ at three years for all qualifications and derive average earnings for those aged 16 and 17 if no formal qualification is obtained.

Another approach is to use Mincer regressions, controlling for other influences, such as experience, which was the method used by O’Mahony and Stevens (2009) and O’Mahony et al. (2012). While this method allows for direct modelling of the impact of education on earnings, it leads to difficult econometric issues, mostly relating to identifying the difference between age and experience. We pursue this approach by modelling the following Mincer regression by sex and four age bands (age 16-19, 20-24, 25-29 and 30-80):

\[
\ln(pay_{it}) = \beta_1 \exp_{it} + \beta_2 \text{training}_{it} + \beta_3 PT_{it} + \gamma' \text{edu}_{it} + \delta_t,
\]

where $\ln(pay)$ is the logarithm of the individual $i$’s gross weekly pay of the first and the second job (should the respondent have one) at time $t$ multiplied by 52 weeks, $\exp$ represents the individual’s years of work experience, $\text{training}$ is a dummy variable to control for any job-related

¹ This assumption is embedded in previous work by Christian (2010) and Gu and Wong (2010).
education/training respondents carried out in the last 4 weeks and $PT$ denotes part-time. The experience variable is constructed by taking the average graduation age at each qualification level and deducting that from the current age at time $t$. We control for education attainment using a vector of covariates ($edu$) representing the highest qualification obtained and employ individual year dummies for 1994-2018. From this model we obtain predicted average wages for full-time work at each of the formal qualification levels by sex and age band, net of a person’s work experience.

The calculations should also take account of the opportunity costs of staying in education beyond the age of compulsory education. However, these foregone earnings are likely to be small relative to lifetime earnings, averaged across the population, so they are not further addressed in this work. Finally we should note that these measures do not take account of depreciation of the human capital acquired through schooling when students enter the labour force and so the output measures are gross, consistent with GDP.

### 2.2.2 Employment, population and absence

Our estimates of education services include increments to the potential HC for those currently enrolled in education. Education yields increments in potential lifetime earnings, even if the individual educated chooses subsequently not to offer their labour services in the market. In many calculations of HC, there is an adjustment for employment propensities, estimated by multiplying current income by employment rates and end of working life retirements (Jones and Fender, 2011). Such adjustments amount to including a utilization rate, which would not be standard practice in national accounting and inconsistent with theory that suggests the private return to capital absorbs changes in utilization (Berndt and Fuss, 1986; Hulten, 1986).

On the other hand, if individuals enrolled in education do not complete their studies, or only partially attend a school year, their future earnings will be affected, and this should be taken into account. For example, in the UK about 4% of sessions in schools are missed due to absence, although only 1% are unauthorised (Department for Education, 2018). Absences, however, tend to be concentrated on specific individuals so that more than 10% of pupils are defined as “persistent” absentees, missing more than 10% of sessions. At the higher education level, the UK Higher Education Statistics Authority (HESA) statistics show that about 10% of students enrolled drop out within one year of starting a degree. Adjusting for these effects, which are fairly standard in the context of approaches that use enrollments as quantity indicators of school system output (see Atkinson, 2005), are in fact a form of utilization adjustment—the stock of knowledge embodied in the students that the school system begins with is not fully utilized over the course of the academic year.

### 2.2.3 Education progression

The UK data are available by type of qualification rather than years of education, divided into four groups: GCSE or equivalent (the typical exam qualification attained usually at the age of 16, requiring grades A*-C), A-level or equivalent (the typical exam qualification for those who stay on at school, usually attained at age 18), further education (FE – post secondary but below tertiary, typically
vocational qualification that can either be a follow on from GCSE or sometimes from A-level) and higher education (HE - tertiary education leading to a degree or equivalent). This means that assumptions need to be made to implement equation (6) in regard to progression across different types of qualifications. We aggregate all students up to the age of 16 and compare their lifetime income when they have GCSE with the lifetime income of someone with the same age but without any qualification. Lifetime income of students aged 18 and 19 who have A-levels are compared with lifetime incomes of those with GCSE aged 17 and 18. FE are compared with GCSE for those aged up to and including 18 and with A-levels for students up to and including age 21. HE is compared to A-levels rather than FE as most students go to University following A-levels rather than progression via FE qualifications. This comparison is carried out for all students aged between 16 and 39.

2.2.4. Volume of education output and deflators

These calculations are in nominal values which can be divided into volume and price components. The volume index of education output, $Q_t^E$, is an index number using Tornqvist aggregation, based on education enrollments. It is calculated as a weighted sum of student enrollments using as weights the increment in lifetime labour incomes due to education, cross-classified by age, sex, and education level (Gu and Wong, 2010). This is given as:

$\ln Q_t^E - \ln Q_{t-1}^E = \sum_{s,a,e} \bar{v} \left[ \ln (enr_{s,a,e,t}) - \ln (enr_{s,a,e,t-1}) \right]$

where $\bar{v}$ is the share of individuals with $s, e, a$ in the total value of education output, averaged over year $t - 1$ and $t$. The price index of education services ($P^{ES}$) can then be estimated by dividing the nominal value of education services by the volume index of education services in (8). This is the deflator used in the calculations below. This price index can be thought of as being quality adjusted, to the extent that demographically-disaggregated earnings cross-classified with formal education experience capture changes in the quality of education services (as valued in the labour market).

3. Application to UK data

3.1. Data sources

We use standard data sources to carry out the computations described above for the UK. These are:

- The cross-sectional quarterly Labour Force Survey for earnings and employment rates by gender, age and qualification.
- The cross-sectional quarterly Labour Force Survey for population estimates by gender, age and qualification which are benchmarked to published ONS estimates by gender and age.
- The longitudinal quarterly Labour Force Survey for enrollment probabilities by gender, age and qualification.
- Department for Education and Skills for school and FE enrollment rates by gender and age.
- Higher Education Statistics Agency (HESA) for HE enrollment rates by gender, age and students’ domicile prior to enrolling in HE.
• ONS Life Tables for survival probabilities.

Enrollment numbers on students in primary and secondary education are obtained from maintained schools (which account for approximately 94% of all pupils in the UK) as well as special schools. Maintained schools are state-funded and funding is disbursed by the Local Authority. We omit private schools, which account for about 9% of total pupils enrolled in education in the UK, as reliable data are not available. Furthermore, we exclude enrollments of part-time students in FE and those aged greater than 21 as these students are likely to be taking courses that are paid for by the individuals themselves or by their employers.

3.2. Results

Consider first the enrollment numbers in the period under study to get an idea of the composition of the UK education sector. Figure 1 shows the total numbers and the division by three groups, school, FE and HE. School is by far the largest group, reflecting that pupils typically spend 11 to 13 years in this form of education whereas they spend only three to four years in HE and about two years in FE. Enrollments in schools were relatively flat up to the mid 2000s but started to increase in recent years. These school enrollment rates are mostly determined by demographic trends. The UK followed a similar path to other countries in having a declining native population up to the late 2000s, but the large-scale immigration witnessed in the 1990s has had a knock-on effect a decade later in raising the school age population. The wave of migrants from EU countries following enlargement has increased the number of children of schooling age, as the migrant were typically young when they entered the UK, settled and then had slightly higher than average family sizes. There were increases in enrollments in HE up to 2012 but a slight dip thereafter. This decline is likely to be a consequence of the introduction of full cost fees for most university programmes in 2012. Both FE and HE show a “financial crisis” effect, whereby students stay on in education in recessions, but it is more pronounced for FE. Figure 1 further suggests higher growth in school enrollments among females, a trend that is observed in many countries.
Table 1 shows a snapshot of the nominal value of education services for 2018 under a number of scenarios. When we account for attribution using average wages a few years after graduation, (T-average), the nominal values decline to 78% of the baseline values. Using a Mincer wage regression increases the magnitude of these adjustments considerably. The adjustments are very large but nevertheless the implied education output figures are about 3 times as large as those in the national accounts, even using the Mincer approach.
Table 1: Education outputs, comparison of variants, 2018

<table>
<thead>
<tr>
<th>Variant</th>
<th>in £ million</th>
<th>Ratio to A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Baseline:</td>
<td>286,042</td>
<td>269,578</td>
</tr>
<tr>
<td>Adjusting baseline for attribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-year average after graduation</td>
<td>251,239</td>
<td>179,399</td>
</tr>
<tr>
<td>Mincer wage regression</td>
<td>128,378</td>
<td>144,659</td>
</tr>
<tr>
<td>Adjusting baseline for:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absenteeism</td>
<td>280,420</td>
<td>263,808</td>
</tr>
<tr>
<td>Dropouts</td>
<td>272,820</td>
<td>254,201</td>
</tr>
</tbody>
</table>

The final two rows show the impact of reductions due to absences and dropouts using estimates by the UK Department of Education for persistent absences and from HESA for students who dropped out after their first year of study. Both lead to small reductions in the baseline, with the higher number for dropouts reflecting both the greater numbers involved and their relatively higher income. Lack of consistent time series on these two adjustments means we cannot add them to the time series discussion below.

Figure 2 shows the index of education outputs, after accounting for attribution, using the Mincer methods, and the quantity measure in equation (8) above. It also shows output per person enrolled. Both series show a steady increase up to 2008, followed by more rapid increase in the period following the financial crisis, and a decline from 2011. Overall for the period 1993-2018, education outputs increased by an annual average rate of 1.02%. Growth in output per person enrolled was lower at 0.53% p.a. mostly reflecting the greater growth in enrollments at the more highly paid HE level. Growth in HE was 1.8% per annum but in schools was only 0.18% p.a. Similar trends are apparent over the period 1993 to 2008, although at higher rates, with real output rising by 1.93% p.a. and real output per person enrolled rising by 1.46% per annum. Thereafter, output declines by 0.33% and output per hour by 0.86% p.a. since the declines in enrollment were concentrated mostly in HE with its higher pay. This illustrates an important finding, that real output growth based on lifetime earnings can be higher or lower than one based on enrollments, depending on the education mix and trends in relative earnings.
4. Incorporating education services into national accounts

The calculations above consider education services from the output side. If such measures were to be incorporated in national accounts, it would be necessary to also consider education services from the expenditure and income accounts. From the expenditure side we can think of public services, such as education and health, as intangible social infrastructure that adds to national investment, savings and wealth. Typically this type of investment is not included in national accounts even though education provides long-lived benefits to society in many forms, including increasing the productivity of workers as well as social gains such as arguably contributing to stable democracies. This section sketches a framework that ensures a consistent treatment within the boundary of the national accounts. A follow on paper will combine this with implications for productivity, with an application to the UK and US.
4.1. Education as Social Infrastructure Investment

As previously indicated, in the social infrastructure framework, society's acquisition of education services is an intangible investment. This investment is defined as the acquisition of schooling knowledge assets and is measured in this paper as the lifetime income generated by an additional year of schooling, $P_t^E Q_t^E$. The real stock of accumulated schooling knowledge assets $S_t$ is held in inventory, within the school system, until students graduate and enter the working age population, after which its value is unchanged (by the school system). The accounting for education that we propose is akin to the treatment of schooling-produced human capital as sketched out in Corrado, Haskel, and Jona-Lasinio (2017) and follows the logic of Ruggles (1983) approach to accounting for consumer durables (see also Moulton, 2001) and the SNA's approach to the treatment of valuables because it is a framework for accounting for changes in stocks that are not “used up” in current production.²

The remainder of this section elaborates the aggregate relationships that govern production, factor payments, and accumulation of schooling knowledge assets in a social infrastructure framework. In this section we assume a closed economy and so abstract from the complications arising from foreign students. The relationship of schooling knowledge assets to conventional measures of human capital in the literature is also discussed.

4.2. Production and factor payments

The output of the education system, $Q_t^E$, is the knowledge held by this year’s graduates, $S_t^{Grad}$, plus the increment to knowledge held by students still within the system $\Delta S_t^{InSchool}$ - we will be more precise about how the corresponding stocks of knowledge evolve in the next subsection. In other words, while the output of schools is graduates, the gestation period for their production spans many years, and the accumulation of knowledge is recorded as value added for each year of schooling until a degree is attained (and/or when a student departs the system). Thus, we have

$$Q_t^E = S_t^{Grad} + \Delta S_t^{InSchool}$$

Note that (9) is functionally equivalent to production defined as “shipments plus inventory change” and, we believe, an apt description of schooling knowledge production.

Given that some students complete school with a secondary education qualification while others remain longer and obtain higher degrees, $Q_t^E$ reflects knowledge accumulation by students at different education levels. It is important to underscore that if $P_t^E Q_t^E$ is the total value of schooling knowledge acquisition in a year (i.e., investment in £s), then $P_t^E$ and $Q_t^E$ are superlative price and volume index numbers whose formulations account for the product composition of the output of the total education industry.

² SNA refers to the System of National Accounts 2008, which are internationally agreed upon standards for national accounts; see European Commission et al. (2009).
The production function for schooling-produced knowledge assets (the output of the education industry) is given by

\[ Q_t^E = A_t^E F^E (L_t^E, K_t^E, S_t^B) \]

where \( S_t^B \) is the beginning-of-period knowledge stocks of school enrollees in period \( t \). As with \( Q_t^E \), \( S_t^B \) is an aggregate comprised of stocks of different “types” of knowledge assets.

The education services production function (10a) represents the schooling-produced increment to human capital generated by labour and capital services, \( L_t^E \) and \( K_t^E \), along with the shift term \( A_t^E \). The shift term allows for changes in the productivity with which inputs are transformed into output in the education industry. \( L_t^E \) and \( K_t^E \) are represented as services aggregates in (10a) because, per the usual productivity accounting, many types of each factor are used in production. Intermediate inputs are ignored for simplicity.

The factor payments equation corresponding to (10a) is written as

\[ P_t^E Q_t^E = P_t^E L_t^E + P_t^E K_t^E + P_t^S S_t^B \]

The price of labour services paid by education institutions \( P_t^L \) is assumed to be competitive by type, determined in the broader economy. The price for fixed capital owned by the sector \( P_t^K \) is a capital rental price, but it is not typical to assume there is a competitive rental rate for capital used in public (or nonprofit) production. The value of education services output is in fact measured as the sum of production costs in the existing national accounts, and its implicit rental price is based on capital consumption, and capital consumption only. In principle, the cost of capital in the user cost for publicly-owned (or non-profit) capital should be the household social discount rate (per Ramsey 1928). Despite considerable variation in how this notion is applied in empirical public finance, it is not unreasonable to assume that there is a consensus rate and that the consensus rate may be applied \( ex \ ante \) to determine the fixed capital rental price \( P_t^K \) in (10b).

As previously indicated, \( P_t^E \) is output price, which in our framework is an investment (or asset) price. \( P_t^S \) is then a capital rental price, i.e., it reflects the marginal productivity of the inventory capital, \( \partial F^E / \partial S^B \) (ignoring differences by type). In other words, ignoring taxes and assuming there is no depreciation of schooling-produced knowledge inventory stocks while students are enrolled in school, the Jorgenson (1963) user cost, \( P_t^S = r S P_t^E \), is assumed to hold.

With measures for \( P_t^E Q_t^E \) and the primary factor inputs, \( P_t^L L_t^E + P_t^K K_t^E \), the user cost formulation may be used to calculate an \( ex \ post \) return \( \rho_t \) to society’s expenditure on education. From equation (10b), schooling-held knowledge assets compensation \( P_t S_t^B \) (or \( S_t^B \) compensation) is

\[ S^B \text{ compensation}_t = P_t^E Q_t^E - P_t^L L_t^E - P_t^K K_t^E \]

from which we can calculate a nominal return as

---

3 The price of labour services is super-scripted by “E” to denote that it reflects the composition of labour by type, which is specific to an industry.

4 Other than child mortality which is likely to be very small
\[ r_t^S = \frac{S^B_{\text{compensation},t}}{P_t^E S_t^E}, \]

and a real return as

\[ \rho_t = r_t^S - \frac{\Delta P_t^E}{P_{t-1}} \]

where, recall, there is no depreciation of schooling-produced knowledge inventory stocks while students are enrolled in school.

### 4.3. Accumulation of schooling knowledge assets

Each school year starts with a “Beginning” stock of knowledge assets \( S_t^B \) and concludes with a “Terminal” stock of knowledge \( S_t^T \). This section reviews the dynamics that affect the evolution of these stocks from year to year. The first dynamic is the increment to knowledge resulting from teaching services provided by the school system during the year, which is reflected in the value of \( S_t^T \) relative to \( S_t^B \). The second dynamic determines how stocks at the close of one year, \( S_t^T \), are related to the beginning-of-period stocks of the following year, \( S_{t+1}^B \).

From the above discussion, we may express production of schooling knowledge assets as

\[ Q_t^E = S_t^T - S_t^B \]

i.e., as the difference between the terminal and beginning stocks of schooling knowledge assets.

Although there is no depreciation of students’ schooling-produced knowledge stocks, to obtain the asset stock held within the school system and available for augmentation in the next period, it is necessary to account for graduates, dropouts, and net migration of new school-age residents, i.e., we need to account for the impact of exits and entrants on \( S_t^T \) to obtain \( S_{t+1}^B \).

The net effect of exits and entrants to/from the school system may be represented as a time-varying proportionate adjustment to the terminal value of inventories from the preceding year. In other words, if the combined effect of graduates, dropouts, and net entrants is represented by the factor \( \gamma_t \), we then have

\[ S_t^B = (1 - \gamma_{t-1}) S_{t-1}^T \]

So, from (12) we can write

\[ S_t^T = Q_t^E + (1 - \gamma_{t-1}) S_{t-1}^T \]

which looks similar to the usual intertemporal relationship between investment and capital in productivity and growth accounts, though the outflows \( \gamma_{t-1} S_{t-1}^T \) are not recurring losses of
productive capital (as in capital consumption), but rather recurring losses from inventory stocks (graduates) flowing into productive use elsewhere.\(^5\)

New entrants at the lowest level of schooling are assumed to have zero knowledge stocks; thus, the new entrant effect on \(S_t^B\) consists of knowledge assets held by net migration of new school-aged residents. It should be noted that combining net migration of new resident students with the recurring process of graduation conflates two types of intertemporal adjustments in the System of National Accounts (SNA). According to the SNA, “recurring losses,” e.g., from inventories (or capital consumption) are to be recorded in the capital account. Net migration of school-aged residents above the entry level is akin to the “economic appearance” of an asset, i.e., a change in real national wealth stocks that is unrelated to national investment. The “economic appearance” of an asset is to be recorded in the other changes in the volume of assets account.\(^6\) Like the capital account, the other changes in the volume of assets account feeds directly into the national balance sheet, i.e., the changes augment (or detract) from national wealth just as real national net investment does, but unlike the capital account, these changes do not require a deferral of consumption.

4.4. Schooling knowledge assets and human capital

Total human capital as set out by Becker (1975) and others includes the impact of investments in education, training, and health care. Total human capital is viewed this way in this paper, with the qualification that investments in formal education reflect production of knowledge via schooling activity only. The time that augments schooling knowledge production in the home is out of scope for both GDP and the model set out in this paper. The modeling of human capital acquisition via work experience versus investments in education was modelled in section 2 above. In related work, O’Mahony and Samek (2019) develop measures of health-adjusted human capital. Training Investments have multiple dimensions, including work experience, but in terms of expenditures, the largest investments are outside of formal education and out of scope for this paper.

The usual approach to measuring the contribution of formal education on human capital looks at its impact over the working lifetime of an individual. In our framework the value of this capital would amount to cumulating each year’s schooling-produced knowledge assets \(Q_t^E\), after accounting for exits from the potential labour force due to death and ageing (recall again we ignore contributions from home production). What we measure in \(S_t^B\), which nets out last year’s graduates and dropouts, is then only a portion of the contribution of education to the total stock of human capital in a population.

The distinction between students still in school accumulating knowledge versus graduates “launched” into the workforce gaining further knowledge through work experience and on-the-job training, is rather central to our approach. In other words, if the stock of total human capital in a

\(^5\) School dropouts and net migration, which are also in \(y\), may of course occur throughout the year; the end-of-year treatment in (5) is for simplicity. Note further that foreign students are considered non-residents; their treatment is discussed in section 5 below.

\(^6\) See Chapter 12 of the SNA (European Commission et al., 2009) for further discussion.
The population is denoted by $H_t$, and the stock potentially available for employment in the economy $\Phi_t$, we have the following:

\[(14a)\quad H_t = \Phi_t + S_t^T\]

Now let $\Phi_t$ evolve to reflect a per period real return, $\omega_t^H$, to work force experience. After accounting for exits due to death and aging (represented as a proportionate reduction, $d_t$, in real stocks) and adding in entrants to the labor market from schools (i.e., exits from schools, from (13a) above), we can write:

\[(14b)\quad \Phi_t = (1 + \omega_t^H)[(1 - d_{t-1})\Phi_{t-1} + \gamma_{t-1}S_{t-1}^T]\]

Note that as conventionally calculated, $\Phi_t$ is a measure of potential labor services, i.e., the stock of human capital available for the workforce. It thus differs from the usual labor services term, $L_t$ in an aggregate production function, which measures actual services utilized in current production.

### 4.5. Consistency with national accounts

These simple accounting relationships are related to the JF lifetime income approach to human capital measurement. Some observers have suggested that the JF “market” component of human capital production could replace the existing measures of education services in conventional GDP (e.g., Ervik, Holmoy and Haegeland, 2003). Our “inventory” approach is a different adaptation of the JF model for inclusion in conventional accounts. In our approach, the production boundary is expanded to include schooling-produced knowledge stocks; savings and investment measures are adjusted for the corresponding flows; and each accounting element includes values, volumes, and prices. In these ways, our approach embraces human capital within the conventional boundary of the SNA.

To see this more clearly consider the “mechanics” that underly our implementation. In existing GDP, education costs are counted as consumption. From the perspective of final demand, consumption of education services consists of an imputed component plus the actual tuition and fees that households pay to educational institutions for education, i.e., teaching, services. Assuming a closed economy and no producer subsidies, the imputed component is the sum of current education production costs less tuition fees. With tuition fees paid recorded as consumption outlays, the sum

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Note that this imputation figures into both income and consumption, so that the transactions affecting personal saving regarding education in existing GDP are benefits paid directly to households to help finance their education (e.g., certain scholarships and prizes, Pell grants in the United States) less the payments made by households.
of actual outlays plus the imputed component equals current education production costs. The imputed component appears in both income and consumption.

When GDP is expanded to include the contribution to current human capital production via formal schooling, our estimate of the schooling-produced increment to human capital replaces the actual education outlays and cost-derived imputed services terms on the expenditure side. Using the estimates in section 3 above, and removing the education sector nominal gross output, we estimate that we add about 16% to nominal GDP. Although generally substantial, it is not nearly as large as the value of investment in human capital relative to existing GDP in Jorgenson and Fraumeni (1992a, 1992b) and Christian, Fraumeni and Samuels (2017).

On the production side we add the net effect of this substitution to the gross output of the education industry. The addition is positive and generally substantial. Conceptually, it expands the implied gross operating surplus (GOS) for the industry to include the implied (annual) return to the current inventory of schooling-produced assets (i.e., the excess of the expected increment to lifetime income relative to its cost. Note that GOS for universities with investments in R&D should already include income payments (or government funds) as partial or complete compensation for these activities, and the current accounting for these investments and payment streams are (in principle) undisturbed by the changes we make. Ditto for, e.g., for-profit hairdresser or IT training schools because our analysis currently exclude these type of education “products” in our analysis.

5. The Treatment of Foreign Students

In viewing education as an intangible asset to be added to the national accounts, a complication arises when the people being educated come from abroad. The knowledge assets of graduates exiting the country needs to be excluded in the calculation of education services as national investment in social infrastructure, and we need to assume that the probabilistic full resource cost of the annual education of foreign students is charged to them (i.e. their charges reflect the costs of their education discounted by the probability they enter the domestic labour force). In this way $P^E$ retains its interpretation as the domestic price of schooling-produced domestic knowledge assets because the cost incurred in producing a foreign graduate is fully offset in revenues. Put another way, education produces a societal asset for another society, and one where the output generated may be based on very different lifetime incomes than in our calculations. Instead the education of foreign students is treated as services exports on the expenditure side of the accounts, and correspondingly, payments by UK nationals to foreign degree-granting institutions are treated as imports. At present we make no correction for the latter in our work, given data constraints but it is likely to be very small.

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8 The accounting is more nuanced when nonprofit institutions are part of the picture (especially when they are substantially compensated by the government as they are in the United Kingdom). But the idea behind the accounting remains the same, namely, that the excess of current costs relative to tuition and fees is imputed as consumption.

9 Because the imputation figures into both income and consumption, the education-related transactions affecting personal saving are the cash benefits paid directly to households to help finance their education (e.g., certain scholarships and prizes) less the actual household payments to education institutions.
In this paper, we distinguish between EU and non-EU students, using unpublished data from HESA, since only the latter are considered “foreign” in the UK. EU citizens, at least up to now, have the right to remain and so arguably should be treated as migrants, some of whom choose to study and some to work. This is a crude assumption since some graduates from EU countries return to their native country and some non-EU graduates remain in the UK. As a result, we are likely to underestimate education services to the extent that some non-EU students remain and work in the UK post-graduation and we overestimate the value by implicitly assuming that all EU students stay and work in the UK. This treatment of foreign and domestic students is necessary due to limited data on foreign nationals working in the UK cross classified by their domicile of study, but can be justified on the grounds that the net effect is likely to be small.

It makes sense in our framework to only include those students who return to their home countries after graduation as exports, given that those who remain add to the societal asset. However, measures of education exports, such as those produced in Department of Education (2017), or ONS and BEA estimates that follow the recommendations of the Manual on Balance of Payments (IMF, 2010) do not make allowance for remaining students, treating all students whose domicile prior to entering education was outside the UK. In this view exports, defined as transactions between UK residents and non-residents, comprise education services provided to students who travel to the UK to procure those services. If these students subsequently choose to remain in the host country they are essentially treated as another person, and only at that point are deemed to be a migrant. This means that conventional estimates of exports of educational services may also need adjustments in our framework.

Figure 3 displays growth in foreign compared to domestic HE male and female students. It shows that much of the growth in this sector in recent years has been in the international market with foreign students in 2018 comprising more than 20% of the HE student population, from less than 2% in the early 1990s. The figure shows further that growth trends have been very similar across both genders regardless of their native country. The obvious exception are foreign students in recent years, where growth has slowed down for males but has continued to be strong for female foreign enrollments.
Figure 4: Growth in enrollments in HE by domicile and gender (000’s), 1993-2018

Note domestic include EU citizens.

Table 2 repeats the numbers in Table 1 but now also shows the reduction in education services when foreign students are excluded. Removing foreign students reduces the baseline figure with no attribution by about 15%. The education output for these foreign students needs, of course, to be added back using conventional exports calculations which include tuition fees and expenditures while they are resident in the UK. A crude estimate suggests the latter is about one third of the value of our lifetime incomes measure so the adjustment is likely to be about 10% in 2018 and smaller for earlier years. This is not as large as the attribution adjustment but is nonetheless substantial.

Overall in our calculations, adjusting for attribution, absence and dropouts, and treating foreign students as exports rather than investments in education, GDP is raised by about 12%. Although still large, an adjustment of this size is more palatable, and is not significantly higher than adding other intangibles, along the lines of those calculated by Corrado, Hulten and Sichel (2005, 2009).
Table 2: Education outputs, comparison of variants, 2018

<table>
<thead>
<tr>
<th>Variant</th>
<th>in £ million</th>
<th>Ratio to A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Baseline:</td>
<td>286,042</td>
<td>269,578</td>
</tr>
<tr>
<td>Adjusting for attribution using Mincer wage regression</td>
<td>128,378</td>
<td>144,659</td>
</tr>
<tr>
<td>Adjusting baseline for foreign students</td>
<td>252,267</td>
<td>233,610</td>
</tr>
</tbody>
</table>

Finally, it is worth summarising the changes to the measurement of educational services proposed in this paper. This is shown in Table 3 which compares the existing treatment in national accounts with our proposed measures, for all three methods for measuring GDP.

Table 3. Comparison of nominal national accounts methods with proposed treatments of education services

<table>
<thead>
<tr>
<th></th>
<th>Current treatment in UK national accounts</th>
<th>Proposed Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>Sum of production costs</td>
<td>Increments to lifetime earnings plus production for exports of educational services delivered to non-permanent residents</td>
</tr>
<tr>
<td>Expenditure</td>
<td>Consumption plus exports of educational services for all non-domiciled students in the UK minus imports</td>
<td>Intangible investments plus exports for non-permanent residents minus imports</td>
</tr>
<tr>
<td>Income</td>
<td>Employment compensation plus capital consumption for national accounts assets (gross operating surplus)</td>
<td>Employment compensation plus gross operating surplus expanded to include society’s expected return to education</td>
</tr>
</tbody>
</table>

The changes have implications for productivity analysis, which are under examination by the authors in current work (Corrado, O’Mahony and Samek, 2019).
6. Conclusion

This paper treats spending on formal schooling as investment, i.e., as social infrastructure, and finds that the framework yields estimates of potential interest to productivity analysts and national accountants. The Jorgenson-Fraumeni lifetime income framework is adapted to develop estimates of (a) education output as the increment to lifetime income due to this year’s schooling and (b) “schooling knowledge inventory,” the amount of knowledge held within the school system until students graduate (or dropout) and enter the labour force. This inventory is an additional factor of production in the economy, and GDP is raised by the value of the return to these stocks. In a case study for the UK, the value added by the education industry is substantially larger in the social infrastructure framework than it is in existing GDP.

We still do not have all aspects of the story for the UK. As well as international trade flows, we need a full breakdown of educations costs and imputations across levels of education to accurately adjust existing national accounts. The rough calculation above on the impact on GDP removed the entire education sector, but some education products would remain, such as sports and recreation education and some vocational education in the form of short courses. Only then are we in a position to develop growth accounting and estimate impacts on productivity. Expanding the social infrastructure approach to include training would help in developing those insights. The intangibles framework already takes the employer-provided training component on board as investment, including it as a component of “economic competencies”, for which estimates of purchases and own-account production are available via INTAN-Invest.

Finally the analysis could be extended in various ways. It might be useful to include cohort effects, as discussed in section 2 above. It might also worthwhile to take account of benefits arising from education other than earnings. For example the finding that graduates lived longer than non-graduates and that valuation of this effect was material when looking at returns to education for men (Dorsett, Lui and Weale (2013). These extensions are left for future work.
References


